PHYSIOLOGY.

# LESSONS

IN

# PHYSIOLOGY.

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# BOOKS OF REFERENCE.

This book is designed to be simply a text book of Physiology, and it is hoped that no one will feel satisfied with the study of it alone. For a more complete discussion of the points considered, consult:

Gray's Anatomy.

Manual of Histology, *Stricker.*

Physiology of Man, *Flint.*

Hand Book of Physiology, *Kirke.*

Physiology, *Draper*, *Dalton*, or *Carpenter.*

Physiology and Hygiene, *Huxley* and *Youmans.*

This book contains a better discussion of Hygiene than most other school Physiologies.

Foods, *Edward Smith.*

The Maintenance of Health, *Fothergill.*

What to do in case of Accident, *John Phin.*

Warming and Ventilation, *Arthur Morin.*

This is an article found in the Smithsonian Reports for the years 1873 and 1874.

# INTRODUCTORY.

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§ 1. The Relations of the Mind and Body.—The mind is the active, intelligent part of man, the body serving as the dwelling place and instrument of the mind. By means of the body the mind gains and communicates ideas, and performs such acts as are prompted by the ideas gained.

§ 2. Psychology.—Psychology is the special study of the Mind, considering the body only so far as is necessary to the complete understanding of the mind.

§ 3. Physiology.—Physiology is the special study of the Body, considering the mind only so far as is necessary to the complete understanding of the body.

§ 4. Divisions of Physiology.—Physiology is divided into three parts: 1. *Anatomy*, which treats of the structure of the different parts or organs of the body. 2. *Physiology*, which treats of the functions or uses of those organs. 3. *Hygiene*, which treats of all those conditions and circumstances, which in any way help or hinder the organs in the performance of their respective functions.

§ 5. Classification of the Organs.—On the basis of the functions which they perform, the organs are divided into three systems: 1. The organs of the *mechanical* system. 2. The organs of the *sensory* or nervous system. 3. The organs of the *repair* system. This classification is shown in the diagram on the following page:

- Organs of the Mechanical System.
  - Bones,
  - Cartilages,
  - Ligaments.
  - Muscles,
  - Tendons.
- Organs of the Sensory System.
  - Primary.
    - Central Organs.
      - Brain,
      - Spinal Cord,
      - Sympathetic Ganglia.
    - Terminal Organs.
      - Rods and cones,
      - Auditory hairs,
      - Olfactory cells,
      - Taste bulbs,
      - Tactile Corpuscles.
    - Connecting organs, Nerves.
  - Accessory Organs..........
    - Skin,
    - Tongue,
    - Nostrils,
    - Ear,
    - Eye.
- Organs of the Repair System.
  - Digestive Organs.
    - Mouth,
    - Teeth,
    - Tongue,
    - Salivary Glands,
    - Pharynx,
    - Œsophagus,
    - Stomach,
    - Gastric Glands,
    - Intestines,
    - IntestinalGlands,
    - Pancreas,
    - Liver.
  - Circulatory Organs.
    - Heart,
    - Arteries,
    - Veins,
    - Capillaries,
    - Lymphatics.
  - Respiratory Organs.
    - Larynx,
    - Trachea,
    - Bronchia,
    - Lungs,
    - Diaphragm,
    - Muscles.
  - Evacuating Organs.
    - Skin,
    - Kidneys,
    - Lungs,
    - Intestines.

§ 6. Liquids of the Body.—The body, composed of the organs named, contains several important liquids: 1. The *blood*, which is the nourishing material of the body. 2. The *chyme*, in the stomach, and the *chyle*, in the intestines, liquids containing materials for renewing the blood. 3. The *saliva*, and *bile*, the *gastric*, *pancreatic*, and *intestinal* juices, liquids which aid in preparing the chyme and chyle. 4. The *lymph*, in the lymphatics. 5. The *mucous* and *serous* liquids, which moisten certain free surfaces. 6. The *urine*, separated from the blood by the kidneys, and the *perspiration*, separated from the blood by the skin, liquids which contain many waste and useless matters of the body.

§ 7. The Processes of Repair.—In the work of the repair system there are several processes: 1. *Secretion*, by which such liquids as the saliva, gastric juice, etc., are formed from the blood. 2. *Assimilation*, by which the different organs take material from the blood, with which to renew themselves. 3. *Excretion*, by which the different organs transfer their waste particles to the blood. 4. *Evacuation*, by which the products of excretion are separated from the blood and thrown out of the body.

§ 8. The Elements Composing the Body.—Oxygen, nitrogen, hydrogen, carbon, and calcium make up the greater part of the body, while sulphur, phosphorus, chlorine, sodium, potassium, magnesium, and iron exist in small quantities.

§ 9. Compounds of the Body.—These elements are combined into several different compounds: 1. Oxygen and hydrogen are combined in such proportions as to form *water*, which is found in all the solids and liquids of the body, making up nearly three-fourths of its weight. 2. Oxygen, nitrogen, hydrogen, and carbon, with a little sulphur, unite to form *gelatin* and *chondrin*, and these five elements with a little phosphorus form *fibrin* and *albumen*. These four compounds are so nearly alike that they are frequently called albuminoids, they are also often called nitrogenous compounds, from the presence of nitrogen in their composition. The albuminoids make up the greater part of the muscles, ligaments, and tendons; they are found in the blood, brain, bones, and in most of the other parts of the body. 3. Calcium, combined with

carbon and oxygen, as *carbonate of lime*, or with phosphorus and oxygen, as *phosphate of lime*, is an important ingredient of the bones and teeth. 4. Sodium and potassium, each combined with chlorine, sulphur, or phosphorus, are found in small quantities in nearly all the liquids of the body. 5. Carbon and hydrogen combine so as to form *oil*, an important ingredient of the body. 6. Magnesium is found with the compounds of lime. 7. Small quantities of iron are found in the blood.

§ 10. THE TISSUES OF THE BODY.—These compounds combine to form the different tissues of the body: as, 1. The *bony* tissue, composed of albuminous or animal matter, and compounds of lime or mineral matter. 2. The *muscular* tissue, composed mainly of albumen. 3. The *connective* tissue, composed mainly of gelatin. In structure, connective tissue is made up of two kinds of fibers, the one white and inelastic, the other yellow and elastic. The yellow fibers are less abundant than the white, and differ slightly from them in composition, as they do not yield gelatin when boiled. The ligaments, tendons, and the investing membranes of the bones, brain, spinal cord, nerves, muscles, and other organs are made up chiefly of white fibers, containing but few of the yellow. A layer of connective tissue composed mainly of elastic fibers, forms the basis of the skin, of mucous membranes which line all cavities exposed to the air, and of serous membranes which line all closed cavities. One coat of the blood vessels and certain ligaments along the back also consists of yellow elastic fibers. 4. The *cartilaginous* tissue, which is composed mainly of chondrin. 5. The *adipose* tissue, which consists of oil packed in cells of connective tissue. 6. The *nervous* tissue, which is composed of albuminous and oily matters, with some compounds of phosphorus, the three held in form by connective tissue. Water is found abundantly in all these tissues.

§ 11. EPITHELIUM.—Epithelium is not properly a tissue, but it is a very important part of the body. All the free surfaces of the body are covered with one or more layers of simple cells, varying greatly in form and in use; these cells are called epithelial cells, or the layer is called epithelium.

This epithelium serves many purposes; that covering the skin serves as a protection; that covering the mucous and serous membranes not only serves as a protection, but secretes a liquid, which keeps these membranes moist and facilitates motion over them. These cells are the active agents in the formation of saliva, gastric juice, bile, etc.

§ 12. MINUTE STRUCTURE OF THE BODY.—Examinations with the microscope show that the different tissues of the body are made up of cells separated by some kind of intercellular substance. This intercellular substance varies greatly in the different tissues; sometimes it is soft, sometimes it is hard; sometimes it appears to be structureless, in other cases it has a fibrous structure. It also varies somewhat in chemical composition. In general, it is the nature of the intercellular substance that distinguishes one tissue from another.

§ 13. GROWTH OF THE BODY.—There is a time when the germ of the body is only a minute mass of homogeneous albumen, containing little rounded bodies called nuclei. This mass has power to assimilate matter and grow. Cells form around the nuclei; these cells multiply, assuming various forms, and the intercellular substance also grows, taking different forms in the different tissues. These processes continue till, from a formless mass, the body with all its parts has been fully developed.

# ANATOMY AND PHYSIOLOGY

OF THE

## MECHANICAL SYSTEM.

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§ 14. Bones—Their Composition.—The bones are hard, inflexible organs, composed of albuminous, or animal matter 33 parts, and of mineral matter, carbonate and phosphate of lime, magnesium, sodium, etc. about 67 parts. The composition of the different bones varies somewhat, and the composition also varies with the age of the bone, the young bone containing more animal matter, the old bone more mineral matter. The mineral matter gives the bone hardness and inflexibility, while the animal matter gives it toughness and elasticity. The animal matter may be removed from a bone by burning it in a common fire. The mineral matter may be removed by leaving a bone from 18 to 24 hours in a solution containing one part of muriatic, or other strong acid, to 4 parts of water. Chicken bones are as good as any for such experiments.

§ 15. Classification of the Bones.—On the basis of form, the bones may be divided into four classes: 1. *Long* bones, as those of the legs, arms, and fingers. 2. *Short* bones, as those of the ankle and wrist. 3. *Flat* bones, as the ribs and the bones of the skull. 4. *Irregular* bones, as those of the spinal column.

§ 16. Structure of the Bones.—The bones have a whitish color, and a smooth, dense, hard surface. If we break a bone and examine its internal structure, we find that

it becomes less dense toward the center, presenting a cellular appearance. The bones of the limbs are hollow cylinders. The cavity of these bones as well as the cellular part of all bones, is filled with a substance something like adipose tissue, called marrow. This structure gives the bones lightness for their size, and strength for the amount of matter they contain.

§ 17. PERIOSTEUM AND CARTILAGE.—Covering the bone closely, is a firm, dense layer of connective tissue, called the *periosteum.* Those parts of the bones which move on each other, in the motions of the body, are covered by a thick, dense, elastic tissue, called cartilage. Cartilage has one very smooth, serous surface. The periosteum and bone are abundantly supplied with bloodvessels and nerves, while the cartilage has but few of either.

§ 18. DEVELOPMENT OF THE BONES.—The places occupied by the bones in a full grown body, were once occupied either by cartilages, as in the case of the long bones, or by membranes of connective tissue, as in the case of some of the flat bones. At one or more places in these cartilages and membranes, compounds of lime began to be deposited in the intercellular substances. This process continues until the bones are fully formed. Compounds of lime are also deposited in the inner layers of the periosteum. The points at which the deposition of the compounds of lime begins, are called points of *ossification.*

§ 19. MINUTE STRUCTURE OF THE BONES.—Even the densest part of a bone is not solid; in it are little channels, called Haversian canals, through which the blood vessels of the periosteum communicate with those of the marrow and interior parts of the bone. Besides these canals, there are little cavities around the cells, and a system of minute passages connecting these cavities with each other, and with the Haversian canals, each filled with nutrient fluid.

§ 20. ARTICULATIONS, OR JOINTS.—Any union of two or more bones is an articulation, or joint. The joint may be immovable, as between the bones of the skull, or it may be movable, as between the bones of the fingers. The bones do not touch each other in any case; when there is no motion a thin layer of cartilage or connective tissue lies between them;

where there is a slight movement, as in the back-bone, they are separated by a layer of elastic fibro-cartilage; in the movable joints the ends of the bones are usually enlarged, and the articular surface is covered with cartilage. The bones are held together at the joints by a band of strong, inelastic, flexible, white-fibrous tissue, called a ligament, which makes the joint a closed cavity. Besides this broad ligament, there are frequently narrow ligaments which aid in making the joint more secure. The cavity of a movable joint is lined with a serous membrane. This membrane secretes a fluid, which keeps the joint moist. The movable joints are: 1. The *ball and socket* joint, as in the shoulder and hip. 2. The *hinge* joint, as in the fingers. 3. The *compound* joints, as the ankle and wrist.

§ 21. Names and Arrangement of the Bones.—The toes of each foot contain 14 bones, called *phalanges*, each foot 5, called *metatarsal* bones, and each ankle 7, called tarsal bones. The tarsal and metatarsal bones are so arranged as to form a low arch on which stand, in each leg, the *tibia* and *fibula;* on the tibias stand the *femurs*, or thigh bones, the two largest bones of the body. The *patellas* are small bones, one in front of each knee joint. On the femurs stands the pelvis, formed by the *sacrum*, *coccyx*, and the two *innominate* bones. On the pelvis stands the *spinal* column, consisting of 24 irregular bones, called *vertebræ.* Each vertebra is made up of a body and seven processes, or projections; 4 by which it articulates with its fellows, 2 upward and 2 downward; one projecting outward from each side, and one backward. These processes are so arranged as to leave an opening, and when the vertebræ are placed upon each other so as to form the spinal column, these openings form a tube, called the *spinal canal.* The five lower vertebræ are called *lumbar* vertebræ, the next twelve are called *dorsal* vertebræ, the upper seven are called *cervical* vertebræ. On the spinal column stand eight flat bones which enclose the cavity of the *cranium*, an expansion of the spinal canal. In front of the cranium are the 14 bones of the face. Extending outward and forward from the sides of the dorsal vertebræ are 24 flat bones, called *ribs*, which, with the sternum in front, partially enclose the

cavity of the *chest*. Projecting outward and backward from the upper end of the sternum are two bones, called the *clavicles*. On the upper and back part of the chest lie two flat bones, called the *scapulas*, or shoulder blades. The upper bone of each arm is called the *humerus*. They join with the clavicle and scapula on each side to form the shoulder joints. Below each humerus are the *ulna* and *radius*, bones of the forearm. The ulna articulates with the humerus, forming the elbow joint. Below each radius are 8 *carpal* bones, which, articulating with the radius, with one another, and with the bones of the hand, form the wrists. In each hand are 5 *metacarpal* bones, and in the thumb and fingers of each hand are 14 *phalanges*. Besides these, there are 16 teeth in each jaw, the *os hyoides* at the base of the tongue, and three bones in each ear, called the *malleus*, *incus*, and *stapes*. There are, therefore, in the complete adult body, 206 bones. Late in life, little bones, called *sesamoid* bones, are developed in the tendons opposite some of the joints in the hands and feet.

§ 22. MUSCLES—THEIR CHARACTERISTICS AND STRUCTURE.—Muscles are distinguished from the other organs by their color, structure, and by their power of contraction under the action of the proper stimulus. Muscles are reddish in color, and make up the greater part of the flesh of the body. They are composed of small fibers, each of which is enclosed in a sheath of strong, elastic, and apparently structureless membrane. These fibers vary in size with age, sex, and use, from 1-1700 to 1-250 of an inch in diameter. In adult males who are engaged in active employment they are larger than in the young of either sex. Neither bloodvessels nor lymphatics pass through the sheath of the muscular fiber.

The fibers are bound into bundles, and the bundles into muscles by a dense, inelastic, fibrous tissue, called *fascia*.

§ 23. CLASSIFICATION OF MUSCLES.—Muscles are either *voluntary* or *involuntary*. The voluntary muscles are under the conscious control of the mind, are rapid in their action, are usually attached to movable organs, and across their fibers are lines which give them a striated appearance. The involuntary muscles are not under the conscious control of the mind, are usually sluggish in their action, are usually so arranged as to

form the walls of cavities and tubes, as in the stomach and intestines, and their fibers are non-striated, or smooth.

The heart and some of the pharyngeal muscles are exceptions, as they have striated fibers and are rapid in their action.

The muscles vary greatly in form. In the extremities they are usually long, while in the trunk they are usually broad and flat.

§ 24. TENDONS.—The voluntary muscles are attached to bones, cartilages, ligaments, and skin by means of bands of white, inelastic, fibrous tissue, called *tendons*. The tendons seem to be composed mainly of a continuation of the tissue which invests the muscles and the bundles of fibers. The manner of the connection of the tendons with the cartilage or bone is not well understood, but this connection is very strong. When attached to the skin, the fibers of the tendons seem continuous with the fibers of the skin.

§ 25. THE ARRANGEMENT OF THE MUSCLES. — The muscles of the trunk are so arranged that they help to form cavities, and at the same time aid in the movements of the body. In the extremities they are arranged in pairs, so that the action of one antagonizes that of the other. One end of the muscle is usually attached to an object that is actually or relatively stationary, while the other is attached to some movable object. Those muscles which bend or flex any part of the body are called *flexors*, while those which antagonize them are called *extensors*.

§ 26. MECHANISM OF THE BODY.—As an instrument or machine, the structure and motions of the body correspond to those of simple machines, as the lever and pulley.

A lever is an inflexible bar which has three important points: 1. The *fulcrum*, the point on which the lever rests. 2. The *working point*, the part applied to the weight. 3. The *point of application*, where the power is applied. Levers are divided into three classes according to the relation of these three points. A lever of the first class has the fulcrum between the working point and the point of application. A lever of the second class has the working point between the fulcrum and the point of application. A lever of the third class has the point of application between the working point and the fulcrum.

The different levers are represented to the eye in the following Figures, in which F stands for fulcrum, W for working point or weight, and P for point of application, or power:

Fig. 1. W F P Fig. 2. F W P Fig. 3. W P

In flexing the arm, the ulna is a lever of the third class. In straightening the arm, the same bone is a lever of the first class. In walking, when the heel is raised, the arch of the foot is a lever of the second class.

In the action of the upper oblique muscle of the eye, and of a muscle which aids in depressing the lower jaw, we have illustrations of the pulley.

§ 27. Elasticity of the Body.—The arch of the foot, the oblique position of the femurs, the *S*-like curvature of the spinal column, the elasticity of the cartilages, bones, and muscles, all aid in preventing shock to the more delicate organs, and in giving the whole body an easy, graceful appearance when in motion.

§ 28. Adipose Tissue.—Adipose tissue consists of oil packed in cells of connective tissue. It is a store of combustible matter for the body; it serves as packing material to fill up the spaces between the organs; it also serves as a protection for delicate structures. A layer of this tissue covers the whole body, giving it a smooth and rounded appearance. This layer also aids in protecting the internal organs from the cold.

§ 29. The Skin.—The skin covers the whole surface of the body, resting on the layer of adipose tissue. It consists of a layer of elastic connective tissue, called the *dermis* or true skin, which is covered by a layer of epithelium, called the *epidermis* or scarf skin. The true skin serves as a protecting organ for the body, and it, in turn, is protected by the epidermis, which in some localities, as in the palms of the hands, becomes thick and of a horny texture. The true skin is abundantly supplied with bloodvessels, lymphatics, and nerves.

§ 30. Hair and Nails.—The hair and the nails are simply modifications of the epidermis. At the bottom of a tubular depression in the true skin, called the *folicle*, is a little projection; a hair is formed by the growth of epidermal cells from this projection. The hair serves to protect the body from heat and cold,

from the effect of blows, etc. The nails are elastic structures of a horny texture. They consist of three parts; root, body, and free portion. That part of the true skin under the body and root of the nail is called the *matrix* of the nail, because the nail is formed by epidermal cells growing from that portion of the skin. The nails not only protect the true skin, but they are useful in other ways. The hair and nails continue to grow during their life.

§ 31. SEBACEOUS MATTER.—In all parts of the skin, except in the palms of the hands and soles of the feet, there are little bodies called glands, which secrete an oily substance called *sebaceous matter*. One or more of these glands opens at the root of each hair. The sebaceous matter differs somewhat in different parts of the skin, and the exact composition is not known, but it always contains more or less oil. Only a small quantity of this matter is secreted, but it is very efficient in softening the hair and skin, and in protecting the skin.

§ 32. CAVITIES OF THE BODY.—The bones and muscles, in addition to performing their functions as parts of the mechanical system, form cavities in which are located the more important organs of the sensory and repair systems. The cranium and the spinal canal are enclosed by bony walls. The chest is bounded by the spinal column, the ribs, the sternum, and a broad muscle called the diaphragm, which separates the chest from the abdomen below.

The abdomen is bounded by the pelvis below, the spinal column behind, the diaphragm above, and on the sides and in front by several broad muscles. Each of these cavities is lined throughout by a serous membrane.

# ANATOMY AND PHYSIOLOGY

OF THE

## SENSORY ORGANS.

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§ 33. Importance of these Organs.—These organs connect all parts of the body so as to make it an organism. It is through these organs that the mind gains ideas of nature, as in seeing, hearing, smelling, tasting, and feeling; through them all movements voluntary or involuntary are controlled; secretion, assimilation, excretion, and in short, all the activites of the body are regulated by means of these organs. Without the sensory system human beings could have no instincts, no volitions, not even a knowledge of existence. The importance of the system makes its study very difficult, so that while whole lives have been spent in studying the different parts, our knowledge of it is still meager and fragmentary.

§ 34. Structure of the Tissue of the Sensory Organs.—The tissue of these organs is made up of two kinds of matter, the one *white*, the other *gray*. The white matter seems only to protect or insulate some portions of the gray matter. The gray matter is made up of two parts: 1. Oval *cells*, each of which contains a nucleus, and usually has one or more projections or branches. These cells are the more active part of the tissue. 2. Minute *fibers*. These fibers vary greatly in appearance; some are enclosed in a sheath of white matter, and are called *medullated* fibers, some have a sheath of connective tissue, some are surrounded by both white matter and connective tissue, and some have no covering, and are called *naked* fibers. In any case the fibers simply convey impressions made upon them, while the cells can receive and originate impressions. A collection of cells, with their connecting fibers, constitutes a sensory center or *ganglion*.

§ 35. CLASSIFICATION OF THE SENSORY ORGANS. — The Sensory organs are, 1. The *sensory centers*, which are the *brain*, a collection of ganglia situated in the cranium; the *spinal cord*, a ganglion in the spinal canal; and the *sympathetic ganglia*, which form a double chain along the front of the spinal column. 2. The *terminal organs*, as the rods and cones of the retina, the auditory hairs of the ear, the touch corpuscles of the skin, the olfactory cells in the nostrils, and the taste bulbs of the tongue. 3. The *connecting* organs or *nerves*, which are bundles of fibers connecting the *central* and *terminal* organs.

§ 36. MEMBRANES OF THE BRAIN AND SPINAL CORD.—1. The *Dura Mater*; this is a dense, fibrous membrane which forms an outer protecting coat for these organs. In the cranium it is firmly attached to the bone, serving as a periosteum for the inner surface of the cranium, but in the spinal canal, it is free from the bony wall. 2. The *Pia Mater*; this is a delicate, vascular membrane which invests the brain and spinal cord closely, following all the irregularities of their surfaces. This membrane is abundantly supplied with bloodvessels, lymphatics, and nerves. 3. The *Arachnoid;* this, a delicate serous membrane, is a closed sack, one wall of which covers the dura mater, and the other, the pia mater. It has no bloodvessels or nerves, as far as known.

§ 37. DIVISIONS OF THE BRAIN.—On account of differences in form, structure, and functions, the brain is divided into three parts; 1. The *Cerebrum*, which occupies the upper part of the cranium, and is the largest of the three. 2. The *Cerebellum*, which is situated just below the back part of the cerebrum. 3. The *Medulla Oblongata*, situated below the cerebrum and in front of the cerebellum. A groove, or fissure, partially divides each of these into right and left halves.

§ 38. THE CEREBRUM.—The cerebrum is ovoid above, a little broader behind than in front, and nearly flat below. The surface is marked by irregular ridges or convolutions, which are separated by grooves about an inch in depth. This arrangement greatly increases the surface of the cerebrum. The convolutions are not symmetrical on the two sides of the same cerebrum, and there is no accurate resemblance between those of different brains. The cerebrum is made up of white matter covered by a thick layer of gray matter which conforms to all the irregularities of its surface.

The gray portion is made up of cells, and of fibers which connect these cells with each other and with other parts of the body. The white portion is made up of these same fibers with their white coating. The fibers are so minute that the whole mass has a white appearance. The fibers which, with their white coating, make up the central portion of the cerebrum, consist of several sets; 1. Those connecting different parts of the same half. 2. Those connecting the two halves, which form a broad band called the *corpus callosum*. 3. Those connecting the cerebrum with the cerebellum. 4. Those connecting the cerebrum with the medulla oblongata. The last named form two bundles, called the *peduncles* of the cerebrum.

§ 39. THE SENSORIUM.—In the lower part of the cerebrum are several masses of gray matter which make up what is called by some physiologists, the *Sensorium*. The most important of these are; 1. The *corpora striata*, which are two masses, one on each side, situated just in front of the center. 2. The *optic thalami*, which are situated just behind the corpora striata. 3. The *optic lobes*, which are four little masses situated between the posterior extremities of the optic thalami. 4. The *tuber annulare*, which is situated in the peduncles. 5. A small mass in the floor of the fourth ventricle, just below and back of the optic lobes. Besides these there are several others which it is not necessary to mention.

§ 40. THE CEREBELLUM.—The cerebellum, or little brain, is about one-eighth the size of the cerebrum. It has a convoluted surface, but its convolutions are more regular than those of the cerebrum, being somewhat similar to folds of cloth. It is composed of gray and white matter, disposed in the same manner as in the cerebrum. The connecting fibers are arranged in three sets; 1. Those forming the *superior* peduncles, which connect the cerebellum with the cerebrum. 2. Those forming the *middle* peduncles, which connect the two halves. These do not extend directly across, as do those of the cerebrum, but pass forward around the peduncles of the cerebrum. 3. Those forming the *inferior* peduncles, which connect the cerebellum with the medulla oblongata.

§ 41. THE MEDULLA OBLONGATA.—The medulla oblongata is about one inch and a quarter long, and a little larger above

than below. Each half is divided by shallow grooves into four parts, which named from before backward are, the *anterior pyramid*, the *lateral tract*, the *restiform body*, and the *posterior pyramid*. The anterior pyramid, the lateral tracts, and some fibers from the restiform bodies are continuations of the peduncles of the cerebrum; while the posterior pyramids and a part of the restiform bodies are continuations of the peduncles of the cerebellum. A mass of gray matter occupies the central part of the medulla oblongata, sometimes called the ganglion of the medulla, and there is also a little mass of gray matter lying on each lateral tract called the olivary body. Many of the fibers of the anterior pyramid cross over and become a part of the right anterior pyramid, and *vice versa*. Such a crossing of fibers is called a *decussation*.

§ 42. The Spinal Cord.—The spinal cord is a cylindrical mass of gray and white nervous tissue, occupying the spinal canal. It is a continuation of the medulla oblongata, extending downward from 15 to 17 inches, and terminating near the first lumbar vertebra. It is divided into halves by anterior and posterior grooves. The gray matter is within the white matter, and so arranged that in a cross section of the cord there may be seen a crescent shaped mass of gray matter in each half, whose convex borders are connected by a short band of the same kind of matter. These crescents of gray matter divide each half of the white matter into three columns, called the *anterior*, *lateral*, and *posterior* columns. The posterior horns of the crescent are the longer, and the division made by them is so much more complete, that many physiologists speak of but two columns, the antero-lateral, and the posterior. The anterior and lateral columns are continuations of the anterior pyramids and lateral tracts of the medulla, and the posterior columns are continuations of the restiform bodies and the posterior pyramids of the medulla.

§ 43. Minute Structure of the Spinal Cord.—The gray matter of the spinal cord is made up of cells having many branches, of naked nerve fibers, bloodvessels, and connective tissue. The white matter consists of transverse, oblique, and longitudinal medullated fibers, of bloodvessels and connective tissue. Some of these fibers have their origin in the gray matter of the spinal cord, but most of them probably arise in the brain.

It is difficult to trace these fibers, but those of the posterior columns seem to decussate along their whole extent, and some of the fibers of the antero-lateral columns do the same, but most of the antero-lateral fibers are longitudinal and parallel, many of them having decussated in the medulla oblongata.

§ 44. THE SYMPATHETIC GANGLIA.—The sympathetic ganglia consist of from twenty eight to thirty pairs situated along the front of the spinal column. There are 4 in the cranium, 3 in the neck, 12 in the dorsal region, 4 or 5 in the lumbar region, 4 or 5 in the sacral region, and one in front of the coccyx, called the ganglion impar. These ganglia are composed of cells, and of naked and medullated fibers. Some of the fibers originate from the cells of the ganglia, some from cells in the brain, and some from cells in the spinal cord. There are several sets of connecting fibers; one connects the individual ganglia of the same pair, another connects the different pairs with those above and below, another connects the ganglia with the brain or spinal cord, and one set forms nerves which connect the ganglia with the various organs depending on them for nervous influence.

§ 45. THE NERVES AND THEIR CLASSIFICATION.—The nerves are bundles of fibers, usually medullated, each surrounded by a sheath of connective tissue, which is continuous with the membranes of the brain or spinal cord. The nerves pass out from the brain or spinal cord in pairs. Twelve pairs passing out through the cranium are called the *cranial* nerves, and thirty one pairs passing out through the walls of the spinal canal are called *spinal* nerves. Some of the fibers of the spinal nerves probably arise from cells in the spinal cord, but most of them are supposed to arise from cells in the brain. Those nerves which arise from the sympathetic ganglia are called *sympathetic* nerves, although it is quite certain that many of their fibers arise in the spinal cord or brain. On the basis of their use, the nerves are divided into two classes: 1. *Afferent*, or *sensitive* nerves, those which carry impressions from the terminal organs to the sensory centers. 2. *Efferent*, or *motor* nerves, those which carry impressions from the sensory centers to other organs.

## THE SENSE OF SMELL.

§ 46. THE OLFACTORY NERVES.—The first pair of cranial nerves, counting from above downward, are the olfactory nerves. They are made up of naked nerve fibers bound together by a sheath of connective tissue. These nerves issue from the anterior part of the cerebrum, but their deep or true origin has not been satisfactorily made out. They pass forward and downward into two irregular cavities, situated in front of the cranium, called the *nostrils.*

§ 47. THE NOSTRILS.—The nostrils are separated by a partition, composed partly of bone and partly of cartilage, and each opens backward into the pharynx, and forward into the air. These cavities are made irregular by three irregularly curved bones jutting out from their sides toward the partition. The nostrils are lined throughout by a mucous membrane, called sometimes the *Schneiderian* membrane, sometimes the *pituitary* membrane.

§ 48. THE TERMINATIONS OF THE OLFACTORY NERVES.—Among the epithelial cells which cover the Schneiderian membrane, in the upper part of the nostrils, there are numerous peculiarly shaped bodies called olfactory cells. The fibers of the olfactory nerves are supposed to terminate in these cells. The olfactory nerves, the nostrils, a portion of the Schneiderian membrane, and the olfactory cells are the organs of the sense of *smell.*

§ 49. THE MECHANISM OF THE SENSE OF SMELL.—Some substance, either gaseous or very finely divided, is drawn through the nostrils with the breath; a portion of this substance is dissolved in the mucus of the upper part of the Schneiderian membrane, the portion dissolved makes an impression on the terminations of the olfactory nerves, probably through the olfactory cells; these impressions, carried by the olfactory nerves to some portion of the brain, cause changes which give rise to the sense of smell.

Each of the organs named, and each of the particulars enumerated, is essential to the sense of smell.

## SENSE OF SIGHT.

§ 50. THE OPTIC NERVES.—The optic, or second pair of nerves, are made up of medullated fibers. They arise mainly from the optic lobes, which are situated just behind the peduncles of the cerebrum. The optic nerves are the nerves of the sense of *sight;* they terminate in a broad expansion called the retina, which is one of the coats of the eye. The course of the fibers in these nerves is somewhat peculiar; they pass around to the front of the peduncles where most of the fibers decussate, so that fibers from the left optic lobes pass to the right eye, and *vice versa.* A few fibers pass directly from their origin to the eye on the same side, some pass around the peduncles and back to the lobe on the opposite side, while others have no connection with the lobes, passing backward from one eye to the decussation, then forward to the other.

§ 51. THE VITREOUS HUMOR AND CRYSTALLINE LENS.—The eyes are globular bodies situated in bony cavities, called sockets, in the anterior wall of the cranium. The nucleus of the eye is a globular mass of transparent jelly-like matter, called the *vitreous humor.* The form of this humor is preserved by a transparent coat of connective tissue, called the hyaloid membrane, which in front consists of two layers. In front of the vitreous body, and between the layers of the hyaloid membrane, there is a transparent, double convex body, called the *crystalline lens.* This lens indents the front part of the vitreous humor, and with it forms more than four-fifths of the eye.

§ 52. THE RETINA.—The vitreous humor serves as a nucleus over which the optic nerve spreads out, forming a coat called the *retina.* The retina covers about two-thirds of the vitreous humor, becoming thinner as it spreads outward, so that it varies from 1-120 to 1-300 of an inch in thickness. It is made up of several layers. The anterior layer is composed of rods and cones which are connected with the fibers of the optic nerves by means of nerve cells and their processes, which form another layer of the retina. In the center of the retina is a yellow spot about one-sixteenth of an inch in diameter, which is made up of closely packed cones and nerve cells, but contains no rods. This is the most sensitive part of the retina. The retina is abundantly supplied with bloodvessels.

§ 53. The Choroid Coat.—Covering the retina is a soft, vascular membrane, called the *choroid coat.* It reaches beyond the retina, so that it covers about four-fifths of the vitreous humor. This coat is composed of three layers. The external and middle layers are made up mainly of bloodvessels, while the inner layer, lying next to the retina, is composed of hexagonal cells, containing pigment granules, which give this coat its brownish color.

§ 54. The Ciliary Processes.—The anterior border of the choroid coat is arranged in folds, which are called ciliary processes. Processes from the investing membrane of the lens and vitreous humor lock into the ciliary processes, thus binding the choroid coat and hyaloid membrane closely together.

§ 55. The Sclerotic Coat and Cornea.—The sclerotic coat is a dense, opaque, fibrous membrane which covers about four-fifths of the eye. It lies next the choroid coat, is slightly elastic, and has but few bloodvessels or nerves. Covering the anterior fifth of the eye and completing the sclerotic coat, is the *cornea.* In structure the cornea is similar to the sclerotic coat, but it is transparent and more elastic, and its curvature is sharper, so that it projects beyond the general curvature of the eye.

§ 56. The Ciliary Muscle.—Attached to the sclerotic coat near its junction with the cornea, by one border, and to the ciliary processes by the other, is a band of fibers called the *ciliary muscle.* Through the connection of the ciliary processes with the capsule of the lens, the contraction and relaxation of the ciliary muscle changes slightly the form of the lens.

§ 57. The Iris and the Pupil.—The *iris* is a muscular curtain attached to the sclerotic coat just in front of the attachment of the ciliary muscle. It is so called on account of its various colors in different individuals. The *pupil* is a circular hole through the iris. The iris is composed of three layers, the most interesting of which is the middle layer, composed of muscular fibers, bloodvessels and nerves. The fibers are non-striated, and are arranged in two sets, one encircling the pupil, and the other radiating from it. The pupil is made larger or smaller as the radiating or circular fibers contract.

§ 58. The Aqueous Humor.—The *aqueous humor* is a thin, watery fluid containing a little common salt and other solid matter. It occupies the cavity between the cornea and the crystalline

lens. The iris divides this cavity into anterior and posterior chambers, which communicate with each other through the pupil. If the aqueous humor be lost by a puncture of the cornea, it is re-formed very rapidly.

§ 59. THE ORBIT OF THE EYE.—The retina is the most important part of the eye. The vitreous humor is an object over which the retina is spread out, while the other parts serve as a protection for it. The eye itself is protected by the bony walls of the orbit, from which it is separated by a cushion of adipose tissue. The orbit so protects the eye that only a blow from a pointed instrument, directed from in front, can injure it.

§ 60. THE EYEBROWS.—The *eyebrows* are arched prominences of skin along the upper margin of each orbit. They lie upon and are attached to a layer of muscular fibers which render them capable of great variety of movements. The brows are well supplied with short, thick hairs, which aid them in protecting the eye from the perspiration of the forehead.

§ 61. THE EYELIDS.—The *eyelids* are two muscular curtains covered with skin, which protect the eye in front, the larger one above, the smaller below. The free border of each lid is stiffened by a layer of cartilage, and along this border are rows of curved hairs, called *eyelashes*. The upper lid has a much more extensive movement than the lower, so that the act of winking is performed mainly by the upper lids. The eyelids and eyelashes protect the eye from dust and other light substances.

§ 62. THE CONJUNCTIVA.—Lining the inside of the eyelids, and covering the cornea and the anterior portion of the sclerotic coat, is a delicate, highly sensitive, mucous membrane, called the *conjunctiva*. It is well supplied with bloodvessels and nerves, except that portion covering the cornea, which has but few bloodvessels in health.

§ 63. THE LACHRYMAL APPARATUS.—Just above the outer angle of the eye is a little gland known as the *lachrymal gland*. It secretes a fluid which is poured out upon the conjunctiva of the upper lid by several tubes or ducts. The act of winking spreads this fluid evenly over the conjunctiva, keeping it moist and freeing it from dust. At the inner angle of each eye are little openings from which passages lead to the nostrils. Through these passages, called *lachrymal canals*, the superfluous fluid passes into the nostrils.

§ 64. THE MEIBOMIAN GLANDS.—Lying between the muscle and the skin of each lid are a number of elongated bodies called *meibomian glands.* They secrete a somewhat oily substance which is conveyed by ducts to the borders of the lids. It serves to prevent the sticking together of the lids, and to prevent the lachrymal fluid from flowing out upon the cheeks. On occasions of great sorrow or joy the lachrymal fluid is secreted in such quantities that it overflows the lids in spite of the meibomian fluid, and falls on the cheeks as tears.

§ 65. THE MUSCLES OF THE EYE.—The movements of the eye are due to six little muscles, four called straight muscles, and two called oblique muscles. The four straight muscles are named superior, inferior, outer, and inner straight muscles. By the action of one or more of these muscles the eye can be moved in almost any direction. The oblique muscles are named the superior and inferior oblique muscles. By their action the eye is rotated as on an axis extending backward through the center of the eye. All these muscles, except the inferior oblique, arise from the back part of the orbit, pass forward, and are attached to to the middle third of the sclerotic coat. The superior oblique passes through a loop or pulley at the upper and inner angle of the orbit, while the inferior oblique arises from the lower and inner angle of the orbit, and is also attached to the middle third of the sclerotic coat.

§ 66. THE MECHANISM OF THE SENSE OF SIGHT. — Rays of light reflected from some object pass through the cornea, aqueous humor, crystalline lens, and vitreous humor, to the retina, where they make an impression on the cones and rods. These impressions conveyed to some part of the brain by the optic nerve, cause changes from which we gain ideas of light and color. Aided by other parts of the eye, the lens so converges the rays of light that a correct image is formed on the retina, if all the parts be in good condition, and the object at a proper distance. Thus by means of the eye we get ideas of light, color, and form.

§ 67. THE FUNCTION OF THE IRIS.—The iris regulates the amount of light admitted to the retina. Too much light makes such a strong impression on the retina that a sense of pain is awakened, and by means of the sympathetic system of nerves, the circular fibers of the iris contract, lessening the size of the

pupil and the amount of light admitted to the retina. When there is not enough light, the radiating fibers contract, enlarging the pupil and admitting more light.

§ 68. THE FUNCTION OF THE CILIARY MUSCLE.—If the lens did not change in form, it is supposed that no object could be seen distinctly, unless it were at a particular distance from the eye. Objects can be seen distinctly at different distances from the eye; hence, it is supposed that the lens does change in form. It is farther supposed that the contraction and relaxation of the ciliary muscle causes this change in form by tightening or loosening the capsule of the lens.

§ 69. THE FUNCTION OF THE CHOROID COAT.—The choroid coat not only serves as a protection for the retina, but the pigment in the anterior layer absorbs the scattering rays of light, thus aiding in the formation of distinct images on the retina, making vision more perfect.

§ 70. THE LINE AND THE FIELD OF VISION.—That part of an object from which rays of light fall on the yellow spot of the retina, is the only part that is distinctly seen. The line from the yellow spot to that part of the object is called the *line of vision.* That space around the line of vision in which objects can be seen with some degree of distinctness, is called the *field of vision.* The area of the field of vision varies somewhat with different persons, but it seldom exceeds four or five square inches.

§ 71. THE PERSISTENCE OF VISION.—The impression made by an object on the retina does not vanish immediately when the object is removed, but remains or *persists* for a short time. This fact may be shown by twirling rapidly a stick with a glowing coal at the end; the impression made upon the retina when the stick is at a given point persists until the stick reaches the same point again, so that there seems to be a continuous line of light instead of only a single point. Winking would interfere with sight if it were not for the persistence of vision.

§ 72. THE VIEW, OR RANGE OF VISION.—By means of the combined action of the muscles of the eye and of other voluntary muscles the line of vision may be turned quickly in any direction. This freedom of motion, with persistence of vision, combines many fields of vision into one *view*, or *range of vision.* From

the view we can get only a few general ideas. The line and the field of vision alone can give us distinct and definite ideas.

§ 73. Binocular Vision.—Binocular vision, or vision by means of two eyes, is more perfect than vision by means of one eye. The field of vision of one eye overlaps that of the other. If we look directly at an object with both eyes, then close one, then the other and at the same time open the first without moving the eyes, the fact stated above will be made manifest. The field of the left eye includes more of the left side of the object, and the field of the right eye includes more of the right side of the object. Philosophers suppose that it is only in this way that we can appreciate the solidity of objects, and that if we had only one eye, all objects would appear flat like a picture, until the other senses had corrected the impression.

§ 74. Visual Impressions of Internal Origin.—The sensorium, spoken of in § 39, is supposed to be the seat of sensations and volitions; and it is supposed that sensations may arise from impressions which come down from the cerebrum, as well as from those carried in from the external organs. Thus in reverie, in dreams, or in delirium we seem to see objects with all their peculiarities of light, color, and form. Such experience shows us that the sensation of sight does not reside in the eye, nor in the optic nerve, but somewhere in the brain.

§ 75. The Third Pair of Nerves.—These nerves, sometimes called the *motor oculi*, are efferent nerves. They arise from the inner side of the cerebral peduncles, having roots in the optic lobes and in other masses of gray matter lying near them.

They pass forward and are distributed to the superior, inferior, and inner straight muscles of the eyes, to the inferior oblique muscle, and to the muscles which raise the upper eyelids.

§ 76. The Fourth and Sixth Pairs of Nerves.—The fourth pair are efferent nerves which arise from the outer side of the peduncles, having about the same deep origin as the third pair. They pass forward and are distributed to the superior oblique muscles of the eyes. The sixth pair are also efferent nerves, having their origin in the floor of the fourth ventricle, near the upper and back portion of the medulla oblongata. They are distributed to the external straight muscles of the eyes.

§ 77. The Terminations of the Efferent Nerves.—The fibers of the efferent nerves have the medullary sheath covered by connective tissue. When these nerves are distributed to striated muscles, the fiber passes through the sheath of the muscular fiber and flattens out on the contractile tissue, sometimes as a disk, and sometimes as branching fibers. The medullary sheath does not pass through the sheath of the muscular fiber, and the connective tissue of the nerve fiber seems to be continuous with the sheath of the muscular fiber. It is through these nerves that the mind controls the activities of the body, and by them we gain a sense of weariness.

§ 78. The Fifth Pair of Nerves.—These are the largest of the cranial nerves, and are composed of both afferent and efferent fibers. Each nerve has a large afferent root arising from the posterior part of the medulla, and a smaller efferent root arising from the anterior part of the medulla. These roots pass upward and outward through the tuber annulare to the cranium just in front of the ear. At this point there is a large ganglion on the afferent root. From this ganglion issue three branches, first, second, and third. The efferent root joins the third branch, so that it only has both afferent and efferent fibers.

§ 79. The Distribution of the Fifth Pair of Nerves.—The first branch is distributed to the skin and muscles of the forehead, to the eye, to the conjunctiva, and to the lower part of the Schneiderian membrane. The second branch is distributed to the teeth of the upper jaw, and to the skin and muscles of the middle part of the face. The third branch sends afferent fibers to the teeth of the lower jaw, to the skin and muscles of the lower part of the face, to the tongue, and to the muscles that move the jaw, called *muscles of mastication.* It also sends efferent fibers to the muscles of mastication.

## THE SENSE OF TOUCH.

§ 80. The Functions of the Afferent Nerves of the Skin and Muscles.—The afferent nerves distributed to the skin generally terminate in small, soft, oval bodies called *tactile corpuscles*, sometimes in larger bodies called *corpuscles of Vater.*

It is through these nerves that we gain ideas of pain and temperature, and those distributed to the skin are the special nerves of the sense of touch, by which we are enabled to judge of the roughness or smoothness of bodies. Those distributed to the muscles are the special nerves of the muscular sense by which we are enabled to judge of the hardness, weight, and strength of bodies.

§ 81. The Seventh Pair, or the Facial Nerves.—These nerves are efferent nerves arising from the sides of the medulla, having deep roots from the same ganglion as the sixth pair. After receiving some fibers from the tuber annulare, these nerves pass outward and are distributed to the muscles of expression in the face, to the muscles of the external ear, and to some others. One branch, the *chorda tympani*, sends fibers to the tongue in the same sheath with some from the fifth pair of nerves. These are supposed to be the special fibers of the sense of taste in the front part of the tongue.

## THE SENSE OF HEARING.

§ 82. The Eighth Pair, or The Auditory Nerves.—These nerves arise near the upper back part of the medulla from the same nucleus as the sixth and seventh pairs. After receiving some fibers from the medulla they pass outward into the walls of the cranium and are distributed to the parts of the internal ear. These nerves are made up of large medullated fibers, which have no covering of connective tissue, and hence are softer than most other cranial nerves. The auditory nerves are afferent nerves, carrying to the brain, as far as known, only those impressions which relate to the sense of hearing.

§ 83. The External Ear.—The organs of the sense of hearing accessory to tbe auditory nerves are the ears, each of which may be divided into an *external*, *middle*, and *internal* ear. The external ear consists of the concha, an irregular cartilaginous plate, somewhat trumpet-shaped in form. The concha is covered with skin and is furnished with muscles, which, however, are seldom used by man. The concha opens into the auditory canal, which extends inward about an inch and a quarter. This canal is formed of bone and cartilage, is narrower in the middle,

and terminates at the membrane of the tympanum. In it grow a few hairs, and near its inner end a peculiar yellow substance, called ear wax, is secreted.

§ 84. The Middle Ear.—The middle ear, or *tympanum*, is like a drum in several respects. It is a bony cavity less than half an inch in diameter, whose ends are closed by membranes, the membrane of the tympanum closing the outer end, while the oval window and round window of the inner end are also closed by a membrane. Three bones, the *malleus*, *incus*, and *stapes*, are so arranged across the tympanum that by the action of certain muscles the membranes of the cavity can be loosened or tightened. And again, this cavity, like a drum, has communication with the air through the *eustachian tube* which leads to the pharynx.

§ 85. The Internal Ear.—The internal ear, or *labyrinth*, is an irregular bony cavity, consisting of three parts, the *vestibule*, *semi-circular canals*, and *cochlea*. The vestibule and semi-circular canals are similar in structure, the walls of each having a periosteum whose free surface is covered by an epithelium which secretes a watery fluid called *perilymph*. Floating in this fluid is a membranous sack similar in form to the bony cavity. The epithelium on the inner surface of this sack secretes a fluid called *endolymph*. Besides the endolymph in the sack, there are little bodies of carbonate of lime called *otoliths*. The cochlea is like a snail shell in shape, the cavity winding two and a half times around the central column. A partition running through nearly the whole length of the cavity divides it into two parts; one, the *scala tympani*, separated from the tympanum by the membrane closing the round window; the other, the *scala vestibuli*, communicates with the vestibule. The whole cavity is lined with a periosteum and filled with the perilymph.

§ 86. The Terminations of the Auditory Nerves.—As the auditory nerve enters the cavity of the internal ear it divides into a *cochlear* and a *vestibular* branch. The vestibular branch is distributed to the membranous sack in the vestibule and semi-circular canals, and its fibers are supposed to terminate in peculiar hair-like epithelium cells which project into the endolymph. In the partition dividing the cavity of the cochlea are passages for nerves and bloodvessels, and a passage called the *canal* of *Corti*, containing a ganglion-like body called the *organ* of *Corti*. From

this organ project more than 8,000 little bodies called the *rods* of *Corti*. On either side of these rods are rows of bodies called inner and outer hair cells. The cochlear branch is distributed to the organ of Corti, and the fibers terminate in these hair cells. The canal of Corti is filled with endolymph similar to that filling the vestibular sack.

§ 87. THE MECHANISM OF THE SENSE OF HEARING.—Sound is a sensation, caused by sonorous vibrations or sound waves acting on the brain through the auditory apparatus. Vibrations of the air, varying in number from 16½ to 38,000 per second, are sonorous vibrations. Some body, as a piano wire, causes sonorous vibrations; some of these vibrations are gathered up by the concha and transmitted along the auditory canal to the membrane of the tympanum, thence along the chain of bones and through the air of the middle ear to the membranes of the oval and round windows, thence through the perilymph to the endolymph and otoliths. The vibrations of the endolymph and otoliths, of the vestibule and semi-circular canals, and the endolymph of the canal of Corti, make an impression on the hair like terminations of the auditory nerves which project into this fluid. These impressions, transmitted to the brain, cause changes which result in the sensation of sound.

§ 88. IDEAS GAINED THROUGH THE ORGANS OF HEARING.—By means of the auditory apparatus we gain some ideas of the distance and direction of the body causing the sonorous vibrations, also some idea of the kind of body, as whether it is a piano, violin, or horn. We can distinguish sounds or tones as high and low, and as high tones are produced by a greater number of vibrations per second than low tones, we can form some idea of the relative number of vibrations which the body is causing. The function of the different parts of the internal ear are not well understood; doubtless experience and the judgment have much to do in forming these different ideas, but it is supposed that the organ of Corti is the most important part of the ear, and that by means of the rods of Corti we are able to appreciate the difference in the pitch of tones.

## THE SENSE OF TASTE.

§ 89. THE NINTH PAIR, OR GLOSSO-PHARYNGEAL NERVES.—These nerves arise from the upper and back part of the medulla near the origin of the seventh and eighth pairs. They consist of three sets of fibers; one set of efferent fibers which are distributed to the muscles of the pharynx, one set of afferent fibers which are distributed to the mucous membrane of the pharynx, and one set of afferent fibers distributed to the mucous membrane of the upper and back part of the tongue. The glosso-pharyngeal nerves communicate freely with the tenth and eleventh pairs.

§ 90. THE TONGUE.—The tongue is a muscular organ covered with mucous membrane, situated on the floor of the mouth. It is a useful organ in the processes of articulation, mastication, and deglutition; and in its mucous membrane are distributed nerves which make it a delicate organ of touch as well as the organ of the sense of taste. Besides receiving fibers from the fifth, seventh, and ninth pairs of nerves, the muscles of the tongue are supplied with efferent fibers by the *twelfth pair*, or *hypoglossal nerves*. These nerves arise from the medulla and are distributed to the tongue, a few small branches supplying some of the muscles of the neck.

§ 91. THE TERMINATIONS OF THE GUSTATORY NERVES.—Projecting from the mucous membrane of the tongue are great numbers of little bodies called *papillae*. The papillae are all similar in structure, and are all well supplied with bloodvessels and nerves. On the basis of form they are divided into four classes: 1. The *circumvallate*, which are larger than the others, fewer in number, and arranged in a V-shape at the back of the tongue. 2. The *fungiform*, or club-shaped papillae, smaller, more numerous, and situated on the anterior portion of the tongue. 3. The *filliform* papillae, smaller and more numerous still, standing thickly over the whole anterior part of the tongue. 4. Simple papillae. The first three classes are made up of large and more or less compound papillae; projecting from these and occupying the spaces between them are the simple papillae. Nerve fibers from the fifth pair and from the chorda tympani are supposed to terminate in the filliform papillae, but the nature of the terminal organ is not known. In the walls of the circumvallate

papillae are little flask-shaped bodies called *taste bulbs*; they are the terminal organs of the fibers from the glosso-pharyngeal nerves.

§ 92. THE MECHANISM OF THE SENSE OF TASTE.—In order that a substance may be tasted it must be in a liquid condition. The article to be tasted is taken into the mouth, and if not already a liquid, it is soon made so by the action of the teeth, tongue, and saliva. This liquid makes an impression on the gustatory nerve fibers, through the taste bulbs and other terminal organs; these impressions carried to the brain give rise to the sensation of taste, by which we are able to say a substance is sweet, bitter, saline, acid, etc. The chorda tympani and the branch of the fifth pair aid in the sense of taste, but the ninth pair are the special nerves of this sense. The fibers from the fifth pair make the tongue a delicate organ of touch by which the same ideas are gained as are gained through the skin.

§ 93. THE TENTH PAIR, OR PNEUMOGASTRIC NERVES.—These nerves arise from the sides of the medulla, having deep roots from the gray matter in the floor of the fourth ventricle near the origin of the seventh and eighth pairs. These nerves are composed of afferent and efferent fibers, and they communicate freely with the ninth and eleventh pairs and with the sympathetic nerves. These nerves pass downward, sending afferent and efferent fibers to the pharynx and larynx, to the trachea and œsophagus, to the lungs and heart, and to the stomach and liver.

§ 94. THE ELEVENTH PAIR, OR SPINAL ACCESSORY NERVES.—These nerves are made up of two parts; one, arising from the medulla, the other, from the spinal cord. They are efferent nerves, sending fibers to the larynx, pharynx, and to some of the muscles of the neck. The twelfth pair was described in § 90. Excepting the first and second pairs, these cranial nerves arise from the medulla, or from gray matter just above it. The origin of the efferent fibers is usually anterior to the origin of the afferent fibers.

§ 95. THE SPINAL NERVES—GENERAL CHARACTERISTICS.—There are thirty-one pairs of spinal nerves grouped as follows: cervical 8 pairs, dorsal 12 pairs, lumbar 5 pairs, sacral 5 pairs, coccygeal 1 pair. Each spinal nerve arises by two roots; one from the antero-lateral part of the cord, known as the anterior, motor, or efferent root; the other from the posterior part of the

cord, known as the posterior, sensitive, or afferent root. The posterior roots are larger, and they have finer fibers than the anterior roots, and on each there is a ganglion, except in the case of the first pair of cervical nerves. Each spinal nerve divides into anterior and posterior branches. The anterior are larger, and are distributed to the skin and muscles of the limbs and the anterior parts of the body, while the posterior are smaller, and supply the skin and muscles of the back in the immediate vicinity of their origin.

§ 96. THE DISTRIBUTION OF THE SPINAL NERVES.—The anterior branches of the four upper cervical nerves supply the skin and some of the muscles of the neck and adjacent parts. The anterior branches of the four lower cervical, and a part of the first dorsal, form an intricate network, or *plexus* of fibers, which sends fibers to the skin and muscles of the upper extremities and the upper part of the chest. The anterior branches of the dorsal nerves supply the skin and muscles of the walls of the abdomen and chest. The anterior branches of the lumbar, sacral, and coccygeal nerves, form tbe lumbar plexus and the sacral plexus, which send fibers to the skin and muscles of the lower extremities and the pelvic region.

§ 97. THE PHRENIC NERVES.—These nerves are made up of branches from the third, fourth, and fifth cervical nerves. They pass downward through the chest, giving branches to the serous membrane of this cavity, and supplying the diaphragm with efferent fibers.

§ 98. THE SYMPATHETIC NERVES.—These nerves are composed of both medullated and naked fibers, which have their origin either in the sympathetic ganglia or in the brain or spinal cord. There are many afferent fibers, but the greater portion are efferent fibers. These nerves send fibers to all the organs of the chest and abdomen and to the muscular coat of the blood-vessels. The sympathetic ganglia in the cranium communicate freely with the branches of the fifth pair of nerves, sending branches to parts of the eye, ear, nostrils, and mouth.

§ 99. THE FUNCTIONS OF THE SYMPATHETIC NERVES.—Through these nerves the mind regulates the processes of assimilation, secretion, and excretion, thus regulating the supply of animal heat. As so many of their fibers are from the brain or spinal

cord, we know but little of the function of the sympathetic ganglia. It seems that they, in some manner, influence the action of the cerebro spinal fibers, since the action of muscles supplied by sympathetic nerves is generally more sluggish than that of muscles supplied directly from the brain or spinal cord.

§ 100. THE FUNCTIONS OF THE CEREBRUM.—With some knowledge of the structure and relations of the different sensory centers, and with some knowledge of the origin, distribution, and function of the nerves, we can better understand the functions of the different sensory centers. Still, with all our knowledge, the parts are so intimately related that it is impossible to give more than a general idea of the particular function of each. The cerebrum seems to be the special organ by which the mind receives and retains those impressions upon which it forms judgments; it is the organ of the *will*, of the faculties of *judgment*, *memory*, *imagination*, *reflection*, *induction*, and of the higher *emotions* and *feelings;* it is also the organ in which originate sensations of an internal origin.

§ 101. THE FUNCTIONS OF THE SENSORIUM.—For the names of the ganglia which constitute the sensorium see § 35. It is supposed that in these ganglia, or by means of them, the mind becomes conscious of impressions brought in by the various afferent nerves. These impressions give rise to ideas, these to desires, and these desires to acts of the will. The impressions made by the acts of the will, through the action of the sensorium, cause voluntary movements; hence the sensorium is said to be the seat of sensation and voluntary motion. While the general voluntary movements are the results of distinct acts of the will, many of the details of these movements are the result of reflex action through the sensorium. As far as known, the cerebellum serves only to coordinate muscular action, so that the muscles act together for a purpose.

§ 102. THE FUNCTIONS OF THE MEDULLA OBLONGATA.—By means of the pneumogastric nerves the medulla regulates the acts of respiration and deglutition, and those branches of the sympathetic nerves which are distributed to the bloodvessels are supposed to have their origin in the medulla, so that it also regulates the circulation and has something to do with the processes of assimilation, secretion, etc.

§ 103. The Functions of the Spinal Cord.—The spinal cord conducts impressions to and from the brain, and is also an independent nerve center. The impressions brought in by the posterior root fibers are conveyed upward by the gray matter of the opposite side of the cord from which they enter, so that there is a complete decussation of the afferent impressions in the cord. It is supposed that the impressions which give rise to the sensations of touch, pain, and temperature, are conveyed to the brain by different sets of fibers. Impressions made by the will on the sensorium decussate in the medulla, pass downward through the anterior columns and the gray matter near them, thence along the fibers of the anterior roots of the spinal nerves, to the muscles.

§ 103. The Spinal Cord as a Sensory Center.—If the spinal cord be so injured in the middle part that the lower extremities have lost sensibility and power of voluntary motion, a very simple experiment shows the cord to be a sensory center. In such a case, if heat be applied to the foot, the impression carried to the spinal cord is converted into a motor or efferent impulse, and the muscles act promptly, while the mind has no knowledge of either set of impressions. Such action is called the *reflex action* of the spinal cord.

§ 105. Paralysis.—The different parts of the body each have some power or property depending upon their connection with some nerve center by means of a nerve. If this connection be destroyed, the part loses this peculiar power and is said to be paralyzed. If the optic nerve be divided, the retina loses sensibility, and the individual loses the sense of sight. If the spinal cord be divided, the parts supplied with nerves from below the division lose the power of sensibility and voluntary motion, and the individual has *paraplegia*.

Owing to the crossing of the fibers in the posterior portion of the spinal cord and in the anterior portion of the medulla, some interesting cases occur; thus, if the left posterior column, including the gray matter near it, be injured, some portion of the lower right side of the body will lose sensibility; while if the right anterior column and the gray matter near it be injured, some part below on the same side loses the power of voluntary motion. An injury in the brain may cause loss of sensibility and power of

motion on the opposite side. When one side is paralyzed, the person is said to have *hemiplegia*. If the spinal cord be injured above the third cervical vertebra, the *phrenic* nerves are cut off from the brain, the diaphragm ceases to act, and the individual ceases to breathe.

# ANATOMY AND PHYSIOLOGY

OF THE

## REPAIR SYSTEM.

§ 106. THE NECESSITY AND FUNCTIONS OF THE REPAIR SYSTEM.—The mind, through the nervous system, controls all the movements of the body, whether voluntary or involuntary. These movements result in waste of tissue. Material is necessary to supply this waste, and organs are necessary to prepare this material for use in renewing tissue, to distribute it to the different parts of the body,and to remove the waste particles. The material to supply the place of waste tissue is *food*, and it is the function of the organs of the *repair system* to prepare and distribute the food and to remove the waste matter. In this work of the repair system there are several distinct processes, as digestion, secretion, circulation, respiration, assimilation, excretion, and evacuation.

§ 107. INGREDIENTS OF FOOD AND THEIR CLASSIFICATION.—From our knowledge of the compounds of the body, § 9, and from experience, we know that food should consist of the following materials: 1. Inorganic substances, as air, water, common salt, compounds of lime, magnesium, potassium, and iron. 2. Organic substances, as albuminoids, oils, starch, and sugar. These materials may also be classified as solid, liquid, and gaseous.

§ 108. The Necessary Conditions of these Substances.—Before food can enter the body to aid in building up the wasted organs, it must pass through the membranes of the lungs, stomach, or intestines. In order to pass through these membranes the food must be in a liquid or gaseous condition. The air is a gas, the water is a liquid, and the other inorganic substances are readily dissolved in water, but the organic substances are not easily dissolved.

§ 109. The Organic Substances—How Dissolved.—In moist air at a temperature of from 40° to 140° F. albuminous substances soon begin to change into liquids and gases, by a process called fermentation. If any of the different kinds of starch or sugar, except grape sugar, be warmed with a little albuminous matter, as the white of an egg, they soon change into grape sugar, which when dissolved in water can easily pass through the membranes of the stomach or intestines. If any of the oils ordinarily used as food, be warmed with a little albuminous matter and water, they break up into small particles, so that a milk-like liquid, called an *emulsion*, is formed. Emulsions can pass through the membranes of the stomach and intestines.

§ 110. Digestion Defined and the Organs Named.—Digestion is the process by which the organic substances of the food are dissolved. This process is carried on in the alimentary canal, which is made up of the mouth, containing the teeth and tongue, the pharynx, œsophagus, stomach, and intestines. The principal agents in the process are the *saliva* secreted by the salivary glands in the mouth, the *gastric juice* secreted by the gastric glands in the stomach, the *pancreatic juice* secreted by the pancreas, the *intestinal juice* secreted by glands in the walls of the intestines, and the *bile* secreted by the liver. These liquids are aided in their work by the teeth and tongue and by the muscular action of the stomach and intestines.

§ 111. The Mouth and Tongue.—The mouth is an irregular cavity in front of the cranium, bounded by bones and muscles. It opens backward into the pharynx, and may be closed in front by the lips. The tongue, situated on the floor of the mouth, is a muscular organ of great importance in the process of digestion. A mucous membrane covers the tongue and lines the mouth. It is continuous with the skin over the lips, and also with the mucous membrane of the nostrils and pharynx.

§ 112. THE TEETH.—In the mouth of an adult there are 32 teeth, 16 firmly set in each jaw. The four front teeth in each jaw are called *incisors*, or cutting teeth, from their shape and use. Immediately outside of the incisors are the *canine* teeth, one on each side in each jaw. They are sharp-pointed and adapted for tearing. Behind the canine teeth are the *molars*, or grinding teeth, five on each side in each jaw. Each tooth consists of three parts; the *root*, the portion in the jaw; the *crown*, the portion outside the jaw; and the constriction between these, called the *neck*. The tooth is mainly made up of *dentine*, the crown being covered with a layer of *enamel*. The dentine is much harder than bone, containing about 72 per cent. of mineral matter; and the enamel is harder still, containing about 96 per cent. of mineral matter. A temporary set of twenty teeth are shed during childhood. The *gums*, composed of dense fibrous tissue, surround the necks of the teeth and are continuous with the periosteum of the jaw. The gums aid in holding the teeth in their places. That the teeth may perform the work for which they seem fitted, the lower jaw is made to move upon the upper in different ways by powerful muscles named the *temporal*, *masseter*, external and internal *pterygoid*. These are called muscles of mastication.

§ 113. THE PHARYNX AND THE ŒSOPHAGUS.—The pharynx, a cavity just back of the mouth, is bounded by non-striated muscles, and lined with mucous membrane. From the pharynx there are seven openings, one to the mouth, one to each nostril, one to each ear, (the eustachian tubes), one to the larynx, and one to the œsophagus. The œsophagus is a muscular tube leading downward through the diaphragm to the stomach. The muscular fibers are non-striated and are arranged in two sets, one longitudinal and one circular. It is lined with a mucous membrane, which is continuous with that of the pharynx.

§ 114. THE STOMACH.—The stomach is a flask-shaped cavity lying across the upper part of the abdomen. Its principal coat is composed of non-striated muscular fibers arranged in three sets, one longitudinal, one circular, and one oblique. The circular fibers form a complete coat; the longitudinal extend the whole length and are continuous with those of the œsophagus, on the one side, and with those of the intestine, on the other; while the oblique are found around that end of the stomach at which the

œsophagus enters. The opening from the œsophagus into the stomach is called the *cardiac* orifice, and the opening into the intestine is the *pyloric* orifice. A band of muscular fibers regulates the passage of material through the pyloric orifice. The muscular coat of the stomach is lined with a mucous membrane in which are situated the *gastric* glands. This mucous membrane is abundantly supplied with bloodvessels, lymphatics, and nerves.

§ 115. THE INTESTINES.—A membranous tube about 20 feet long, extending downward from the pyloric orifice of the stomach is called the small *intestine*. It opens into a larger tube about 5 feet long called the large *intestine*. The principal coat of the intestines consists of two sets of non-striated muscular fibers, the one longitudinal, the other circular. Each is lined throughout with a mucous membrane, which in the small intestine lies in transverse folds, called *valvulæ conniventes*, so that the surface of the mucous membrane is much more extensive than that of the tube it lines. The stomach and intestines are covered with a serous membrane, which is a portion of that lining the cavity of the abdomen.

§ 116. SECRETION.—Secretion is the process by which an organ takes materials from the blood and changes them into a substance which is useful to the body. Such a substance is called *a secretion*, and the organ forming it is called *a secreting* organ. A secreting apparatus may be simple or complex, the essentials in either case being a delicate and apparently structureless membrane resting on a network of bloodvessels, and covered with a layer of epithelium scales.

§ 117. GLANDS.—Glands are secreting organs which vary greatly in form and structure. A gland may consist simply of a *tubular* depression in a membrane, or the tube may be coiled at the deeper extremity, or it may be expanded so as to be flask-shaped, or it may branch like a tree, each branchlet ending in a little sack, the whole forming a compact cluster. In this case, the branchlet is a tube for conveying the liquid formed in the little sack, to the common tube or *duct* which conveys it to some locality where it may be of use. The essentials of a secreting apparatus are present in each sack and tube.

§ 118. THE SALIVARY GLANDS.—The salivary glands consist of three pairs, situated in the walls of the mouth. 1. The *Parotid*

glands, which are situated just within the angles of the jaw. These are the largest of the salivary glands. 2. The *Submaxillary* glands, situated under the jaw about midway from the chin to the angles of the jaw. 3. The *Sublingual* glands, situated under the tongue. Besides these there are numerous smaller glands situated in the mucous membrane in different parts of the mouth. These glands are similar in structure, each consisting of a cluster of cells or sacs, abundantly supplied with bloodvessels and nerves.

§ 119. THE SALIVA.—The fluid secreted by these glands is called the *saliva*. It is a watery fluid containing 994 parts of water and about 1 1-2 parts of albuminous matter, called *ptyaline*, a little more than two parts of mineral matter, with some mucus and fat. The saliva from the glands is alkaline, but it soon becomes neutral or acid when mingled with the acid mucus of the lining membrane of the mouth. The saliva serves to moisten all parts of the mouth, to aid in dissolving the food, and by means of the ptyaline causes starch to change into grape sugar.

§ 120. MASTICATION. — A portion of food placed in the mouth is soon cut, ground, and dissolved into a semifluid mass by the action of the teeth, tongue, and saliva, and the ptyaline of the saliva has commenced changing the starch into grape sugar. The process by which these results are accomplished is called *mastication*.

§ 121. DEGLUTITION. — When mastication is finished, the tongue gathers the food into a mass and throws it back into the pharynx; the muscles of the pharynx contract and force it into the œsophagus; the longitudinal fibers in the walls of the œsophagus contract, thus shortening the tube, while the transverse fibers contract successively behind the food, forcing it downward into the stomach. This process is called *deglutition* or swallowing. No change takes place in the food during this process.

§ 122. THE GASTRIC JUICE.—In the mucous membrane of the stomach there are a large number of tubular glands which secrete a fluid called the *gastric juice*. In one thousand parts of gastric juice there are about 994 parts of water, a little more than 3 parts of albuminous matter, less than 1 part of hydrochloric acid, and also a little common salt, with traces of other

mineral matter. The albuminous matter is called *pepsine*. The pepsine aided by the acid causes the albuminous matter of the food to become a liquid, called *albuminose*.

§ 123. STOMACH DIGESTION.—The presence of the food in the stomach excites the gastric glands to activity, and gastric juice is poured out in great quantities. The presence of the food also stimulates the muscular coat of the stomach to action, and from the peculiar arrangement of its fibers it keeps the food in motion about the stomach, thus enabling the gastric juice to mingle with it more completely and quickly. The gastric juice changes the albumen into the fluid albuminose, and the oil and starch which were bound up in the albumen are left floating in the fluid, so that the whole mass becomes a thick fluid called *chyme*.

§ 124.—THE PANCREAS AND PANCREATIC JUICE.—Situated just below the stomach is a long, flat gland called the *pancreas*. It is similar to the salivary glands in structure, and the *pancreatic juice* which it secretes is similar to the saliva, containing about 12 parts in 1000 of albuminous matter. This fluid is poured into the upper part of the small intestine. Its special office seems to be to change the oil of the food into an emulsion. It also aids in changing starch and cane sugar into grape sugar, and it digests some albuminous matter which has not been digested in the stomach.

§ 125. INTESTINAL DIGESTION. — The greater part of the liquids, the salt and grape sugar of the food, and the albuminose pass through the walls of the stomach into the bloodvessels, but the oil, the starch, some kinds of sugar, much of the gastric juice, and the indigested matter pass into the small intestine. In the mucous coat of the small intestine are numerous glands which secrete a fluid called the *intestinal juice*. By the action of the intestinal juice, pancreatic juice, and bile, the oil is changed to an emulsion, the starch and different kinds of sugar to grape sugar, and the digestion of the albumen is completed.

§ 126. THE LIVER.—The bile, a secretion of the liver, in some unexplained way aids in the intestinal digestion. The liver is the largest gland in the body, weighing three or four pounds. It is situated in the upper part of the abdomen, on the right side. It is convex above, concave below, and is divided into two unequal lobes. The liver is a very vascular organ, being traversed

by four distinct sets of vessels; 1. The *portal vein.* 2. The *hepatic artery.* Both these carry blood to the liver. 3. The *hepatic* or *bile ducts*, which carry bile from the liver. 4. The *hepatic veins*, which carry blood from the liver. The liver is made up of a great number of little bodies about 1-25 of an inch in diameter, called *lobules.* The portal vein and hepatic artery enter the liver from below, through the fissure which divides it into lobes; then dividing into minute branches, they occupy the spaces between the lobules, and are called *interlobular veins.* From these interlobular veins a fine network of bloodvessels penetrates each lobule, converging to a common vein in the center, which is called an *intralobular vein.* The intralobular veins transfer the blood to the hepatic veins, and they to the heart. In the lobules, the liver forms bile and sugar. The sugar is of a peculiar kind and its use is not known.

§ 127. THE BILE AND ITS FUNCTIONS.—In 1000 parts of bile there are 880 parts of water, 90 parts of *biliary salts*, about 13 parts of fatty matter called *cholesterin*, the remaining parts being made up of mineral and coloring matters with a little mucus. The biliary salts are true secretions, which are supposed to aid in the digestion of oil. The cholesterin and coloring matter are excretions, separated from the blood by the liver for evacuation through the intestine. The bile also stimulates the action of the muscular coat of the intestine, acting as a natural laxative.

§ 128. SUMMARY OF DIGESTION.—In the mouth the food is reduced to a pasty mass, and under the action of the saliva the starch has begun to change to sugar. In the stomach the albumen is changed to albuminose by the gastric juice, so that the whole mass becomes a thick fluid, called *chyme*, in which indigestible portions of food are floating. The water, mineral matters, much of the albuminose and sugar pass from the stomach into the bloodvessels, the other portions pass into the small intestine, where the intestinal and pancreatic juices soon convert the starch into sugar, and the pancreatic juice and bile convert the oil into an emulsion, so that the whole mass has a milky appearance and is called *chyle.* The nutrient portions of the chyle, and much of the digestive fluids pass into the bloodvessels and lymphatics; while the indigested and waste matters along with various excretions received from the walls of the intestines, pass downward, and are evacuated.

§ 129. Absorption.—Projecting from all parts of the mucous membrane of the small intestine are little tubes called *villi.* They are so numerous and so fine that the whole mucous surface feels like velvet. In the mucous membrane of the stomach and in the villi of the intestine there are numerous bloodvessels and lymphatics. The nutrient portions of the food pass freely into these vessels, which are said to absorb the materials, and the process is called *absorption.* The greater part of the emulsion is absorbed by lymphatics, and the milky color of this fluid has given the name of *lacteals* to these vessels. The greater part of the water, grape sugar, and albuminose is absorbed by the bloodvessels. The bloodvessels take up some emulsion, and the lacteals some water, albuminose, and sugar.

## CIRCULATORY ORGANS AND CIRCULATION.

§ 130. The Blood.—The blood, into which we have followed the nutrient portions of the food, is a red, opaque, slightly alkaline fluid, a little heavier than water. The blood forms about one-ninth of the weight of the body. While digestion is going on the quantity increases somewhat. According to Flint Vol. I, Page 138, the composition of the blood is about as follows:

| | |
|---|---|
| Corpuscles, red and white | 495.3 |
| Albumen | 329.9 |
| Water | 154.8 |
| Fibrin | 8.8 |
| Mineral matters | 6.8 |
| Fatty matters | 1.4 |

Also some undetermined matters and gases.

§ 131. The Blood Corpuscles.—The red corpuscles, which are most abundant, are soft solids about the consistency of honey. They are circular bodies about 1-3500 of an in inch in diameter, shaped something like a coin that is thicker along the edge than at the center. They seem to be homogeneous, having no nucleus, nor granules; they are very elastic and have an amber color, due, it is supposed, to iron. The white corpuscles are larger, oval in shape, contain granules, and are like the corpuscles found in other fluids of the body. There are four or five hundred red corpuscles to one white corpuscle.

§ 132. Coagulation of the Blood.—On exposure to the air the fibrin of the blood hardens into strong fibers which entangle the corpuscles; these fibers contracting, squeeze out the liquid portions from the corpuscles, thus separating the blood into two parts; the fibrin and corpuscles form a hardened mass called the *clot*, and the water, albumen, etc., a liquid mass called the *serum*. This hardening of the blood is called *coagulation*. It is nature's method of stopping the flow of blood from wounds, the clot serving as a plug to close the orifice from which the blood flows.

§ 133. The Circulation.—The blood not only contains nutrient material for each organ, but it is the only means by which the organs can get rid of their waste matter; thus for two reasons the blood must pass around to all parts of the body. This passage of the blood through the body is called the *circulation*. During a circuit it receives nutrient material from the intestine, gives it up to the different organs, takes up their waste matter, and gives it up again to some evacuating organ. The tubes through which the blood flows are the arteries, capillaries, and veins, and the organ that causes the blood to flow is the *heart*.

§ 134. The Heart.—The heart is a hollow muscle, conical in form, and about the size of the fist. It is situated in the chest, so that the base is behind the breast bone, while the apex points downward and to the left between the fifth and sixth ribs. There are four cavities in the heart: 1. Two, called ventricles, right and left, which have thick walls and constitute the bulk of the heart. 2. Two, called auricles, which have thinner walls and a less capacity than the ventricles. The heart is surrounded by a fibrous coat called the pericardium. A serous membrane lines the pericardium and covers the outer surface of the heart, and a similar membrane lines the cavities of the heart, which is sometimes called the endocardium. Between the auricles and ventricles there are membranous curtains, called valves. On the right side the valve has three points and is called the *tricuspid* valve. On the left side the valve has only two points and is called the *mitral* valve. The valves prevent the blood from passing into the auricles from the ventricles. The mitral valve is more perfect than the tricuspid valve.

§ 135. The Arteries.—Blood is sent out to all parts of the body through the arteries. There are two principal arteries: 1. The

*Aorta*, which, arising from the left ventricle, divides and subdivides till every part of the body is supplied with arteries; 2. the *Pulmonary* artery, which arises from the right ventricle, divides and subdivides till every part of the lungs is supplied with arteries. The branches of these two arteries are called arteries as long as they are more than about the 1-2500 of an inch in diameter. The arteries are membranous tubes whose walls are made up of three coats. The external and toughest coat is composed of connective tissue containing a large number of yellow elastic fibers; the middle coat is composed of muscular and yellow elastic fibers, which lie in a direction more or less transverse to the length of the artery. In the larger arteries there are more of the elastic fibers in the middle coat, but in the smaller there are more of the muscular fibers. The internal or serous coat consists of a brittle membrane with some elastic fibers, which is covered with a delicate layer of epithelium. In the aorta, just as it leaves the left ventricle, there are three half-moon-shaped membranous curtains called *semilunar* valves, which prevent the blood from flowing back into the ventricle. There are similar valves in the pulmonary artery.

§ 136. THE CAPILLARIES.—The arteries finally terminate in a network of vessels of minute size, called *capillaries*, which pervade every part of the body. The capillaries vary somewhat in size, but will average about 1-3000 of an inch in diameter, and about 1-30 of an inch in length. The walls of the capillaries are composed of a delicate elastic membrane in which are found oval nuclei. While the capillaries differ in structure from the arteries, the change is so gradual that there is no sharp line of division between the two sets of vessels.

§ 137. THE VEINS.—The greater part of the blood is gathered up from the capillaries in the different parts of the body and conveyed back to the heart through the veins. The veins are similar to the arteries in structure, except that the middle coat of the veins is thinner than that of the arteries, and that the internal coat frequently lies in folds so as to form valves which prevent the blood from flowing toward the capillaries. The veins which receive blood from the capillaries of the lower part of the body flow together into one large vein, called the *vena cava inferior*, which opens into the lower part of the right auricle. Those from

the upper part of the body unite in the *vena cava superior*, which opens into the upper part of the right auricle. The pulmonic vein which receives blood from the pulmonic capillaries, opens into the left auricle. The walls of the arteries and veins are well supplied with bloodvessels and nerves. The veins are supposed to have about double the capacity of the arteries.

§ 138. THE PULSE.—In children less than a year old the left ventricle contracts about 130 times in a minute, gradually decreasing through childhood and youth until in middle age it contracts about 70 times per minute in men, and about 78 times in women. In extreme old age the contraction is somewhat more rapid. The blood forced out by each contraction of the left ventricle causes a wave-like impulse throughout the aorta and its branches. This impulse expands the arteries and is called the *pulse*. In several places arteries lie so near the surface that the pulse can be felt. The most common place for feeling the pulse is the wrist on the thumb side. It may be felt on the inside of the arm between the shoulder and the elbow, just behind the clavicles or collar bones, on either side of the larynx, and just in front of each ear, also in the instep, in the flexion of the knee joint, sometimes on the inside of the leg, between the hip and knee, and in front of the pelvis about midway between the hip joint and the middle line of the body.

The blood flows more rapidly in the larger, than in the smaller arteries, more rapidly in the arteries than in the veins, and more rapidly in the veins than in the capillaries. In the large arteries it flows from 10 to 12 inches in a second, in the capillaries about 1-30 of an inch in a second. The time in which the blood makes a complete circuit is variously estimated at from 30 to 40 seconds.

§ 139. LYMPHATICS.—A portion of the serum of the blood passes through the walls of the capillaries into the tissues of the body. That portion not used by the tissues is gathered up by a system of tubes, called *lymphatics*, which convey it into large veins near the heart. The lymphatics of the intestines, during digestion absorb chyle, and from the milk-like color of this fluid, they have been named *lacteals*. The lymphatics of the lower extremities, and of the abdominal organs, unite, forming a tube called the *thoracic duct*, which conveys the lymph and chyle upward through the *thorax* or chest, and pours them into the left

subclavian vein. Through numerous branches it receives all the lymph from the left half of the body above the diaphragm, pouring it into the vein with the other matters. The lymph from the right half of the body above the diaphragm is poured into the right subclavian vein. In structure the lymphatics are like the bloodvessels, but they have thinner walls and more numerous valves. Muscular action aided by the valves is probably the cause of the current in these tubes. In connection with the lymphatics are numerous glandular bodies called lymphatic glands. Their structure and use are not well understood. The white corpuscles of the lymph and blood are supposed to originate in these glands. These glands are found in the axillæ, neck, abdomen, and in other localities.

## RESPIRATORY ORGANS AND RESPIRATION.

§ 140. THE RESPIRATORY ORGANS NAMED.—The material brought to the heart by the veins and lymphatics is not good blood; it cannot nourish the tissues. The changes necessary to make this material good blood take place in the lungs, the most important of the respiratory organs. The impure blood passes to the lungs through the pulmonary artery from the right ventricle, and the pure blood passes from the lungs to the left auricle through the pulmonary vein. The respiratory organs are the larynx, trachea, bronchia, lungs, and such parts of the mechanical system as are engaged in the movements of respiration.

§ 141. THE LARYNX, TRACHEA, AND BRONCHIA.—The larynx is a cartilaginous box situated just below the pharynx, opening upward into the pharynx through the *glottis*. The glottis may be closed by the action of muscles, and it is partially protected by the *epiglottis*, which acts as a valve. The larynx opens downward into the *trachea*, which is a membranous tube about 4 1-2 inches long and about 3-4 of an inch in diameter. The trachea divides into two tubes called *bronchia*, which again divide and subdivide till the minute branches terminate in sacs, called *air cells*. The trachea, the bronchia, and their larger branches are kept open by more or less complete cartilaginous rings, but in the smaller branches of the bronchia and in the walls of the air cells muscular and elastic fibers exist. The larynx, the trachea,

the bronchia, and their branches are lined throughout with a mucous membrane; the walls of the smaller tubes and of the air cells seem homogeneous, but they have a mucus surface.

§ 142.—The Lungs.—The lungs are two organs, conical in shape, situated one in each side of the chest. They are separated by the *mediastinum*, a cavity which occupies the center of the chest, containing the heart, the thoracic duct, the œsophagus, numerous bloodvessels, lymphatics, and nerves. The lungs are made up of the bronchia, the air cells, the branches of the pulmonary artery and vein, lymphatics and nerves, all bound together with connective tissue. The bronchus, bloodvessels, nerves, and lymphatics enter the lung together near its upper part, and form what is called the *root* of the lung. A delicate serous membrane, called the *pleura*, covers each lung as far as the root, where it is reflected to the walls of the chest, which it lines, so that in any movement of the lungs or the walls the serous surfaces move over each other.

§ 143. The Mechanism of Respiration.—Respiration is the act of introducing air into the lungs, and of forcing air out of the lungs. The ribs, which form the walls of the chest, are not horizontal, when at rest, but incline downward; when lifted to a horizontal position by the contraction of the intercostal muscles, the cavity of the chest is enlarged forward. The diaphragm, which forms the floor of the chest, when at rest, is shaped like an inverted bowl; when it contracts, the arch is flattened and the cavity of the chest is enlarged downward. Air has the property of mobility, and presses downward and sidewise with a force of 15 pounds on every square inch. As the elevation of the ribs and the depression of the diaphragm enlarge the chest, this pressure forces air through the nostrils or mouth, through the pharynx, larynx, trachea, and bronchia, into the lungs, so distending them that they follow closely the walls of the expanding chest. As the muscles relax, the ribs sink down, the arch of the diaphragm rises, pushed upward somewhat by the action of the abdominal muscles, the cavity of the chest is lessened, and a quantity of air is expelled from the lungs. The muscular and elastic fibers of the lung tissue aid greatly in forcing air from the lungs. The object of respiration is to furnish oxygen to the blood and relieve it of carbonic acid.

§ 144. THE FREQUENCY OF RESPIRATORY ACTS.—The respiratory acts of an adult male while sitting quietly are about 20 per minute; they are more frequent in youth and while engaged in active exercise, and less frequent in advanced life and during sleep. The amount of air changed at each respiration is from 20 to 30 cubic inches.

§ 145. THE CAPACITY OF THE LUNGS.—In a medium sized healthy adult male the *residual* air, or air that cannot be expelled from the lungs by a forcible expiration, is about 100 cubic inches. The *reserve* air, or air which can be expelled, but which is not changed during ordinary respiration, amounts to about 100 cubic inches. The *tidal* air, which is changed at each respiration, amounts to from 20 to 30 cubic inches. The *complemental* air, which may be taken into the lungs after an ordinary inspiration, by a forced inspiration, amounts to about 110 cubic inches. The extreme capacity of the lungs is, therefore, about 330 or 340 cubic inches. The residual and reserve air may be called stationary air, as it is not disturbed by ordinary respiration.

§ 146. THE CHANGES IN THE BLOOD AND AIR FROM RESPIRATION.—In the process of respiration the air loses oxygen and gains carbonic acid, water-vapor, and a trace of animal vapor; while the blood loses these three substances and gains oxygen. The walls separating the air and blood are very thin, and in some unexplained way this interchange of material between the air and blood goes on through these walls. This interchange takes place between the stationary air and the blood. Two bodies of air cannot lie side by side without mingling, each diffusing rapidly into the other. Of the 20 or 30 cubic inches of air taken in at each inspiration, a large portion is thrown out at the next expiration, but some diffuses downward, becoming stationary air, while some of the stationary air, with carbonic acid, water-vapor, and animal vapor, diffuses upward and is thrown out by expiration.

§ 147. CATALYSIS.—As the blood leaves the lungs it has the composition given in § 130. It contains no albuminose, no grape sugar, no emulsion. The changes taking place in the liver and lungs may account for the disappearance of a portion of these substances, but the greater part has been changed into blood by the process of *catalysis*. Catalysis is the process by which certain substances by their presence "or contact" cause changes in

other substances. This process has never been satisfactorily explained, but it is important in various vital phenomena.

§ 148. ASSIMILATION.—The blood passes from the lungs along the pulmonary veins to the left auricle; thence through the mitral valve into the left ventricle; thence through the semilunar valves into the aorta, and through its branches into the capillaries in all parts of the body. As the blood passes through the capillaries, each organ takes from it materials, which, by catalysis, it changes into material like itself. The process by which an organ takes material from the blood and with it renews itself, is called *assimilation*. The albumen of the food becomes albuminose by the action of the gastric juice; the albuminose becomes albumen of the blood by catalysis, and the albumen of the blood becomes an ingredient of bone, muscle, connective tissue, etc., by the process of assimilation.

§ 149. EXCRETION.—As the waste resulting from the action of the different organs cannot pass unchanged into the blood, each organ during assimilation is taking material from the blood, mainly oxygen, which it combines with this waste, forming compounds which can pass into the blood. Carbonic acid, cholesterin, water-vapor, urea, and other substances are formed in this way and poured into the blood. These substances are called *excretions*, and the process of forming them is called *excretion*. Each organ is an excreting organ as well as an assimilating organ.

§ 150. EVACUATION.—The excretions make the blood impure, they are hurtful to the body, they are poisonous, and must be taken from the blood and removed from the body. The process of removing useless and harmful material from the body is called *evacuation*. The most important evacuating organs are the intestines, lungs, kidneys, skin, and liver. The materials which are separated from the body by means of the lungs are mentioned in § 146. Cholesterin is separated from the blood by the liver, and discharged from the body through the intestines along with the indigestible and non-nutritious portions of the food.

§ 151. THE KIDNEYS AND THEIR OFFICE.—The kidneys are two bean-shaped organs, situated, one on either side of the spinal column in the lumbar region just behind the *peritoneum*, or lining membrane of the abdomen. They are composed of a firm, dark red substance, and are covered by a fibrous capsule. They are

made up of a great number of narrow, convoluted tubes, called *tubuli uriniferi*, around which is spread a dense net-work of capillaries. Besides these, lymphatics and nerves are abundant. The kidneys separate from the blood the ingredients of the urine, which are *water*, *urea*, *uric acid*, *creatine*, *creatinine*, common *salt*, and others. These ingredients exist in the blood, and are filtered from it into the tubuli uriniferi without change. The urea is probably formed from broken down albuminous matter of the tissues, or from an excess of albuminous matters of food. Creatine and creatinine are probably formed from broken down muscular tissue.

§ 152. THE SKIN AS AN EVACUATING ORGAN.—The skin protects the body from heat and cold, and from contact with other objects, it secretes an oily substance for its own protection, in it are the terminations of the nerves of the sense of touch, and in addition to these it is an important *evacuating* organ. Besides the sebaceous glands, there are found in the skin great numbers of coiled tubes, about 1-16 of an inch in length, called *sweat* glands. These glands separate from the blood a fluid called *perspiration* or *sweat*. In 1000 parts of sweat there are of water 996 parts, common salt about 2 parts, and urea, carbonic acid, and some other substances in small quantities. The quantity of perspiration varies in different individuals, and in the same individual, with health, temperature, and occupation. The amount separated from the blood by a man under ordinary circumstances is estimated at about 2 pounds in 24 hours.

§ 153. SUMMARY OF THE LOSSES AND GAINS TO THE BLOOD.—The blood loses:

1. By the *Lungs*, carbonic acid, water-vapor, and animal vapor.
2. By the *Kidneys*, water-vapor, urea, uric acid, creatine, creatinine, common salt, etc.
3. By the *Skin*, water, urea, carbonic acid, common salt, etc.
4. By the *Liver*, water, cholesterin, biliary salts, coloring matters, and sugar.
5. By the *Organs generally*, constructive materials.
6. By the *Secreting organs*, secreted fluids.

The blood gains:

1. From the *Alimentary Canal*, water, lime compounds, common salt, albuminose, grape sugar, and emulsified fat.
2. From the *Lungs*, oxygen.
3. From the *Liver*, sugar.
4. From the *Organs generally*, excreted matters.
5. From the *Lymphatics*, lymph.

§ 154. ANIMAL HEAT.—The human body maintains nearly a uniform degree of heat amid great variations of the temperature of the air. This heat is called *animal heat*. The average temperature of the mouth is about 99° F, of the whole body probably about 100° F. This temperature is maintained by the changes which occur in the processes of assimilation and excretion, and the amount of change in these processes depends largely on the amount of oxygen received through the lungs. This temperature is subject to slight variations: it is higher during the labor and excitement of the day than during the rest of night, it varies slightly in different parts of the body, usually in accordance with the supply of blood. The liver is said to have a higher temperature than any other organ. Lack of good food in sufficient quantity results in a depression of the temperature, while a diet of oily and starchy foods results in an increased temperature. The adult has more power to resist cold than either the very young or very old person. Hope, joy, and anger are said to elevate the temperature, while fear and distress depress it. The temperature is depressed slightly by cold, and elevated slightly by heat, but perspiration evaporating from the skin prevents much increase of the heat of the body from external sources.

# HYGIENE.

§ 155. Hygiene—Its Importance.—Hygiene is the science of health; it treats of those conditions which aid or hinder the organs in the proper performance of their functions. The better understanding and the better observance of these conditions by all classes in England, has reduced the death rate from 1 in 20 in 1685, to 1 in 40 in 1865. In France, the annual death rate has been reduced from 1 in 25 in 1772, to 1 in 45 in 1846, through a more intelligent observance of the laws of health. It is estimated that the average age of man has been increased about 25 per cent. within the last 50 years, through more correct habits of living. Hygiene depends on Physiology and Anatomy, and if the matter of the foregoing pages has been mastered, Hygiene can be studied intelligently.

## EXERCISE.

§ 156. Exercise—Its Necessity.—As the organ of the mind, the body must have been designed for action; judging from its structure, it was designed for action. If the different organs of the body are designed for action, then some exercise is necessary. Experience shows that judicious exercise promotes digestion, quickens the circulation, strengthens the muscles, and stimulates the processes of secretion, assimilation, excretion, and evacuation, making the body in every way a more perfect instrument for the mind, and thus enabling the mind to work more vigorously and effectively.

While, in general, we live more nearly in accordance with the laws of health than did the ancients, they gave much more attention to exercise than we do. Socrates and Plato were physical as well as intellectual athletes.

§ 157. The Conditions under which Exercise should be Taken.—1. *Exercise* should be taken in *pure air.* It is only from pure air that the blood can get a proper supply of oxygen. If the blood is not well supplied with oxygen, assimilation, excretion, and animal heat are defective, and the body is not in health. 2. *Exercise* should be taken in the *full light of day*, and if possible, there should be more or less exercise in the *sun light.* In some unexplained way sun light, or the light of day, promotes the vigor of all the vital processes. The habits of man and animals and the general experience of mankind testify to the importance of exercise in the broad light of day, or sun light. 3. *Exercise* should be taken *regularly.* If by acts of the will we perform certain work at certain times, the result is that very soon this work can be done unconsciously, and it seems to us as if the body had habits. But a little thought assures us, that while the action is unconscious, it is the mind still that has directed the action of the body. When the exercise is regular the mind unconsciously sends out nervous energy and blood to the parts that are to be exercised, so that they are prepared for work, but if the exercise is irregular, time is lost in getting the parts ready for work. 4. *Exercise* should *begin* and *close gradually.* If the exercise be regular, an extra supply of nervous force and blood will always be ready at the time, but a full supply of each only begins to come as the parts begin action, and time is necessary to take blood and energy from other parts and concentrate them on the more active parts. If the exercise close suddenly, the nervous energy and blood not needed oppress the parts till an equilibrium is established, while by closing the exercise gradually the equilibrium may be established without oppression or shock. 5. During exercise the *position* and *clothing* should be such that every part is allowed the utmost *freedom* of action. A cramped position may prevent free respiration, may prevent the free flow of the blood, and the proper action of the muscles and nerves; close-fitting, inelastic garments may do the same things. Every muscle, bloodvessel, and nerve, should have complete freedom of action during exercise. 6. *Exercise* should be taken in a temperature averaging from 40° to 60° F. Experience shows that temperatures much above or below these do not promote a healthy, vigorous action of the organs. 7. *During* exercise the *mind* should be in a *tranquil state.* In regular exercise the

mind can often attend to other affairs without injuring the value of the exercise, but any thing that profoundly impresses the mind, as grief, joy, fear, or any exitement lessens the accuracy and value of muscular or mental activity. The exercise to be valuable must be interesting and agreeable. 8. *Exercise should be limited.* Weariness comes on when the blood fails to supply materials for assimilation, either in the brain or muscles. During exercise excretion exceeds assimilation, and if the exercise continue too long, the body loses rather than gains by the exercise.

§ 158. THE BEST EXERCISE.—For the muscles, that exercise is best which employs the greatest number of muscles, and is most interesting to the mind. That exercise is best for the brain which brings all its parts into activity. Judicious exercise strengthens the muscles, makes the brain more efficient, and promotes all the vital processes; while lack of exercise allows the muscles to become weak, the brain sluggish, and the whole system to become diseased and inefficient.

## REST.

§ 159. REST — ITS NECESSITY. — The result of exercise, whether of the brain or muscles, is waste of tissue, which causes a sense of weariness. The sense of weariness may be relieved for a time by *rest*, or a cessation of exercise. During rest, assimilation exceeds excretion, the sense of weariness passes away, and the body is ready for exercise again. A change of exercise, so that another set of organs is brought into action, may serve as rest.

§ 160. THE AMOUNT OF REST NECESSARY. — Experience shows that, in the case of the brain or muscles, the periods of rest should equal the periods of exercise or work. During the day, from six to eight hours may be given to intellectual labor, and from eight to ten hours to rest, which may consist of light, muscular exercise, lighter intellectual exercise, conversation, etc. The one who labors vigorously for eight hours with his muscles needs eight hours of rest, which may consist of lighter muscular exercise, intellectual exercise, conversation, etc. In most cases the customs of society prevent such a division of time, but the above suggestions, faithfully carried out, would undoubtedly promote the physical and intellectual growth of a people.

§ 161. The Conditions under which Rest should be Taken.—Rest should be taken, 1. Regularly. 2. In pure air of an agreeable temperature. 3. As much as possible in the full light of day. 4. In such a position, and in such clothing that every organ has the utmost freedom of action. 5. In a tranquil state of mind. Rest of the proper amount and kind taken under these conditions will be beneficial.

## SLEEP.

§ 162. Sleep—Its Necessity.—Rest alone cannot keep the body in condition for exercise. After eight hours of work, and eight hours of rest, there should be eight hours of sleep. During the time of both work and rest the mind is more or less active, so that the brain cannot rest. It is only during sleep that the brain rests, and that its waste is renewed; the rest of sleep is also necessary to the complete renewal of other tissues.

§ 163. The Time to Sleep.—The best time to sleep is during the darkness of night, but whether during the early or later part of the night depends on circumstances and habit. A person engaged in muscular labor goes early to bed, rising early next morning. The student finds if he has not overworked during the day, that his mind works better during the quiet of evening, than during the bustle of the morning, so he usually sleeps during the after part of the night. The person engaged in muscular labor who sleeps well, may work 10 or 12 hours per day for a long time without bad results, but the one engaged in intellectual work, if he would maintain good health, must divide the day into three equal parts, one for work, one for rest, and one for sleep.

§ 164. Some Effects of Overwork.—The brain, as the special organ of the mind, is the most important organ of the body, and receives more blood, in proportion, than any other organ. Hereditary taint, a diseased liver, stomach, or kidney, by vitiating the blood, impairs the nutrition of the brain and deranges the action of the mind. The most common cause, however, of deranged action is *overwork* of the brain. Overwork means working so many hours that there is not time for sleep; it means such intense work as causes the brain to become congested with blood, causing head-ache and preventing sleep;

it means the severe strain incident to stock jobbing, commercial operations, business embarrassment, etc. The diseased condition of the brain resulting from overwork manifests itself so frequently in sleeplessness, that it is considered a symptom of grave disorder in the brain. Sleeplessness, at first a result, becomes a cause, increasing the disorder of which it is a symptom.

§ 165. Favorable Conditions for Sleep.—The best time to sleep is during the quiet and darkness of night. Whenever we sleep, it should be in pure air of a temperature of from 40° to 60° F., and under covers just sufficient for comfort. The bed should be soft enough and elastic enough to conform to the body and support all its parts. The position should be such that all the voluntary muscles are relaxed, and the muscles of respiration free to act, and such that all the bloodvessels and nerves are free to perform their functions. It is perhaps best to sleep on the right side, yet many sleep on the back, or on the left side without inconvenience; lying on the face and chest impedes the action of the respiratory organs. The young, the healthy, and those with tired muscles sleep easily, even under unfavorable circumstances; but the aged, the sick, and those with tired brains must make special efforts to procure sleep.

§ 166. Means of Promoting Sleep.—Regularity, quiet, a recumbent position, monotonous sounds, familiar surroundings, all tend to promote sleep. The tired brain is usually oppressed with blood, and until the oppression is relieved, it will be impossible to get refreshing sleep. Let vigorous mental work cease a full half hour before the time for sleep, walk briskly in cool, fresh air, engage in pleasant conversation, read some humorous book, take a little food, or in some way relieve the brain of the surplus blood; if this can be done, sleep will usually come easily. In the case of the sick and aged, it may be necessary to use some medicine, as alcohol, or opium, but they should be used only under the direction of a physician.

## FOOD.

§ 167. Food—Its Importance.—Rest and sleep are not sufficient to keep the body in condition for exercise. A large quantity of material, called *food*, or *ingesta*, must be taken into

the body each day for the purpose of building up tissue, of maintaining animal heat, and of aiding in the various processes of repair. The proper materials for food, the proportion, quality, and quantity of each, the manner of the preparation of the food as well as the time and the manner of eating, and the surroundings while eating, are all important subjects in the study of hygiene. For the different ingredients of food, their composition, and their classification, consult § 107.

§ 168. SOURCES OF THE DIFFERENT INGREDIENTS OF FOOD.—The animal kingdom furnishes large quantities of albuminoids and oils; the vegetable kingdom furnishes starch and sugar with some of the albuminoids and oils; the mineral kingdom furnishes water, lime compounds, common salt, iron, oxygen, phosphorus, potash, sulphur, etc. The following tables from "Food," by A. H. Church, will give some idea of the relative quantity of the different ingredients in 100 parts of the various articles, which are commonly used as food in the temperate zone in this country:

| | | | | |
|---|---|---|---|---|
| Eggs— | Albuminoids | 14.0 | Oil | 11.0 |
| Milk— | " | 4.1 | " | 3.7 |
| Butter— | " | 1.0 | " | 88.0 |
| Cheese— | " | 29.2 | " | 29.6 |
| Beef— | " | 8.0 | " | 30.0 |
| Mutton— | " | 5.0 | " | 40.0 |
| Pork— | " | 4.5 | " | 50.0 |

In birds and fish the albuminoids are abundant while the fats are scanty and frequently absent.

| | | | | | | |
|---|---|---|---|---|---|---|
| Oat Meal— | Albuminoids | 16.1 | Starch | 63.0 | Oil | 10.1 |
| Wheat Flour— | " | 10.5 | " | 74.0 | " | 0.8 |
| Rye Flour— | " | 10.5 | " | 71.0 | " | 1.6 |
| Indian Corn— | " | 9.0 | " | 64.5 | " | 5.0 |
| Buckwheat— | " | 15.0 | " | 63.6 | " | 3.4 |
| Rice— | " | 7.5 | " | 76.0 | " | 0.5 |
| Beans— | " | 23.0 | " | 52.0 | " | 2.3 |
| Potatoes— | " | 2.3 | " | 15.4 | " | 0.3 |
| Sweet Potatoes— | " | 1.5 | " | 15.0 | —— | |

The sugar of commerce is obtained mainly from the sugar cane, sugar beet, and sugar maple, but the common fruits contain it in great quantities; apples contain about 7, grapes about 13, bananas about 19, and figs about 57 per cent.

Onions, cabbage, celery, lettuce, tomatoes, turnips, cucumbers, and some other garden vegetables contain from 90 to 95 per cent. of water. Potash is furnished by rhubarb, grapes, strawberries, apples, lemons, etc.; sulphur is found in eggs and onions; iron in cabbages, potatoes, and most other vegetables; phosphorus in wheat, rice, oats, milk, and many other articles of food; lime compounds are found in many vegetables, but the most abundant supply is derived from well and spring water.

§ 169. The Best Proportion of Food Materials.—The albuminoids contain material for building up tissue, and for the maintenance of animal heat as well, hence they and the compounds of lime are sometimes called the essential elements of food. Starch and sugar, composed of hydrogen, carbon, and oxygen, with oil supply materials for maintaining animal heat, and with other ingredients of the food are called accessory elements of food. The body needs about 22 grains of carbon and hydrogen for every 5 grains of nitrogen. One pound of lean meat might furnish nitrogen enough for one day, but 4 or 5 pounds would be necessary to furnish the needed amount of carbon and hydrogen. Such a diet would involve a great waste of nitrogen and give the excreting and evacuating organs overwork. A combination of the different ingredients is found to be better than any of them alone. The following table from "Food," by A. H. Church, shows the amount of the different articles of food, that will furnish about the proper quantities of each of the food elements for one day:

| | | |
|---|---|---|
| Bread | 18 | oz. |
| Butter | 1 | " |
| Milk | 4 | " |
| Bacon | 2 | " |
| Potatoes | 8 | " |
| Cabbage | 6 | " |
| Cheese | 3.5 | " |
| Sugar | 1 | " |
| Salt | 0.75 | " |
| Water alone and in tea, etc. | 66.25 | " |
| Total about 6 pounds, 14 1-2 ozs. | | |

In addition to these matters taken into the alimentary canal, the body receives from the air through the lungs about 1 pound, 10 1-4 ounces of oxygen, making a total of about 8 pounds, 8 3-4 ounces of foreign matter taken into the body every 24 hours.

The amount assimilated is somewhat less, as some of the food material is not digestible. According to A. H. Church, in "Food," the actual daily supply and waste is about 8 1-2 pounds for a man of ordinary activity.

§ 170. THE QUANTITY AND KIND OF FOOD.—The amount of exercise, rest, or sleep necessary in any individual case often varies widely from the average given, so the amount of food necessary varies with age, sex, occupation, temperature, health, etc. In youth, food must supply waste, maintain animal heat, and in addition it must furnish materials for growth. For adult persons the amount of food necessary must depend on the amount of work done, and on temperature. In old age and in a very cold climate, more of the oils, starch, and sugar are needed, while the laboring man in a warm climate needs more of the albuminoids.

§ 171. THE QUALITY OF FOOD.—Every article of food should be of the best quality. Water and salt should be pure, vegetables should be fresh, and free from all appearance of disease or decay. Meat should be the flesh of healthy, well-fed animals; it should be firm, juicy, and of a bright, uniform color. Fruits and meats preserved by *drying*, fruits and other vegetable products and meats preserved by *canning*, are good substitutes for the fresh articles; meats preserved by *smoking* and *salting*, while not as good as fresh meats, are valuable articles of food.

§ 172. THE MANNER OF COOKING FOOD.—The object of cooking should be to develop a flavor, and so to change the food that the digestive fluids can more easily act upon it. In cooking meats, a high degree of heat should be applied at once, so that a thin crust is formed over the surface, which will retain the natural juices, then if the heat is continued at a little lower degree, the fibers of the meat are softened and separated by their own juices. If cooked too slowly or too long, the juices are evaporated, the characteristic flavor is gone, and there is but little difference in the taste of the meat of different animals.

In cooking vegetables, the idea is still to soften the fibers and develop a flavor. Starch exists in little sacs, which vary in form and size in different plants; a temperature of 212° causes the sacs to burst, and the starch then becomes a homogeneous mass easily

acted upon by the digestive fluids. The heat needs to be applied for a much longer time in cooking preparations of maize than in cooking most other forms of starch.

In making soups or broths the articles should be cut into small pieces and cooked slowly.

No article of food should be so cooked that fat is disseminated through the mass: The oil prevents the digestive fluids from entering and acting on the material so cooked.

Good wheaten bread is one of the best articles of food. In whatever way bread is made, it should be light and sweet, and free from all uncombined chemicals, as soda, cream of tartar, saleratus, etc.

A suitable variety of well selected and well cooked food is necessary to a healthy, vigorous condition of the body.

§ 173. Pastry.—Pastry is eaten not so much for its nourishing qualities, as for its agreeable flavor. Eaten at the close of the more substantial part of the meal, it often overloads the stomach; eaten between meals, it interferes with the rest of the stomach. Eaten under these circumstances, pastry is often the cause of disease. When eaten in small quantities at regular meals, well cooked pastry is not harmful. Food, poor in quality and badly cooked, may be a source of disease; but overeating, rapid eating, and eating at irregular intervals are much more common causes of disease.

§ 174. Water and its Uses.—Water is the most important of the liquid foods. It is not only important as a food by itself, but it forms the greater part of other liquid foods, as tea, coffee, wine, beer, etc. Water is not a food in the sense that the albuminoids are food, as it does not aid in building up tissue, nor in generating heat. It aids in dissolving the solid food for absorption; it carries the food around to the different organs, and also carries away their waste. Water may be called the common carrier of the body. It is found in every liquid and solid of the body, and without it not an organ could perform its functions. The importance of water, and the quantity necessary each day makes the question of the supply of good water a very important one.

§ 175. Water Supply.—For drinking purposes rain-water, water from surface or shallow wells, river water, and water from

deep wells or springs is used. Chemically pure water does not exist in nature. The solvent power of water is very great; it dissolves more substances than any other liquid; it also absorbs many gases. Rain-water absorbs oxygen, nitrogen, carbonic acid, ammonia, nitric acid, and other gases from the air; it also gathers from the air dust of organic and inorganic matter, and it is farther contaminated by accumulations of filth on the roofs from which it is collected. Such water is not fit for drinking purposes, especially if gathered in or near manufacturing towns. Surface or shallow well water in addition to the impurities contained in rain-water, is liable to contain impurities dissolved from decaying vegetable or animal matter. Surface water is especially liable to contamination from stables, cess-pools, vaults, and from various manufacturing establishments. The special poisons of typhoid fever and of cholera may be dissolved in surface water. No natural water which is exposed to the air and light, is ever free from vegetable growth. Surface water is generally unfit for drinking. River water usually contains more mineral matter, but is better than surface water, as the oxygen of the water oxidizes many of the impurities into harmless compounds. The sewage of a town or city will render the water of a river unfit for drinking purposes for many miles. Spring water or water from a deep well is usually free from all organic impurities, but is frequently charged with mineral substances, as sulphur, iron, soda, potash, or lime. Water containing salts of lime is called hard water. Water from deep wells and springs is most likely to be fit for drinking, as the impurities of the rain and shallow well water have been filtered out by the soil through which it has passed.

§ 176. WATER—HOW PURIFIED.—Distilled water is more nearly chemically pure than any natural water, but it is not palatable. Rain-water collected toward the close of a long shower is quite pure, the rain having washed all gases and dust out of the air in the early part of the storm. By boiling water all the gases are expelled, all animal and plant life destroyed, and much of the lime compounds precipitated. Water that has been boiled, if made palatable with sugar and milk, is a pleasant and wholesome drink while warm; and if allowed to stand long enough to absorb oxygen, it makes a palatable drink when cold.

The most common method of purifying water is by *filtration.* Sand is often used as a filter, but the best filter in common use is

one made of alternate layers of sand or gravel and charcoal. Bricks are also used as material in constructing a filter. Charcoal is most efficient. It absorbs vast quantities of the noxious gases, and the oxygen it contains soon changes them into harmless compounds. For filtration on a large scale, nothing has been found better than a well made sand filter. Good surface draining or sewerage will keep much decaying vegetable and animal matter out of surface water and shallow wells.

§ 177. TEA.—Tea is a beverage made by steeping the leaves of the tea plant in water of a temperature just below the boiling point, in a close vessel. Tea is a gentle stimulant to the nervous system; it quickens the circulation and promotes digestion. If used intemperately it causes a diseased state of the nervous system, which manifests itself in wakefulness, irritability, headache, etc. Be sure not to use adulterated teas. Green tea is more liable to produce injurious effects than black tea. Fresh teas have a better flavor than old teas. Cold tea is an excellent beverage, especially during hot weather.

§ 178. COFFEE.—Coffee is a beverage made from the coffee bean. The coffee bean contains about 15 per cent. of a substance similar to sugar, and about the same amount of nitrogenous matter, and nearly the same amount of fat and volatile oil, also a vegetable alkali, called *caffeine*, which, in tea, is called *theine*. Caffeine or theine is supposed to be the active principle of both coffee and tea. The volatile oil is developed by heat and furnishes the aroma of the beverage. To make good coffee, the coffee bean should be roasted and ground; one portion of this should be boiled in water about five minutes, to extract the active and nutrient properties; let it settle, pour off the fluid, and in it steep the second portion without boiling, which will extract the volatile oil; let it settle the second time, then pour off the liquid for use. Made in this way coffee is refreshing, nourishing, and palatable. Its effects are much the same as those of tea, and it is equally harmful when used in excess. Tea, coffee, and alcoholic liquors in small quantities seem to retard tissue change and lessen the need of solid food. It is well established that tea and coffee enable men to endure cold and fatigue much better than alcoholic beverages.

§ 179. WINE AND BEER.—From one to two ounces of absolute alcohol, if well diluted and slowly taken, can be digested

by an adult person each day. Thus taken alcohol is a food. It does not build up tissue, but it helps to maintain animal heat, quickens circulation, promotes the digestion of other kinds of food, and aids in assimilation. Wine or beer containing from 4 to 10 per cent. of alcohol, if taken at meals as we take tea and coffee, produces about the same effect that those beverages produce, and are especially beneficial to those persons who have a sluggish circulation or weak digestive powers. The intemperate use of these substances is attended by such frightful consequences that one needs to use them wisely, considering the effect on himself and on his friends. Stronger wines, rum, gin, brandy, and whisky may sometimes be useful as medicines, but never useful as food.

§ 180. Other Accessory Foods.—Cocoa and chocolate when well prepared are refreshing and nutritious beverages. When used in moderate quantities, some of the vegetable acids are valuable, as citric acid from lemons, malic acid from apples, oxalic acid from rhubarb, tartaric acid from grapes, etc. The various condiments, as mustard, pepper, ginger, cloves, etc., make some articles of food more palatable, and in some way aid in digestion. Tobacco and opium may sometimes be useful as medicines, but never as foods.

§ 181. Temperature of Food and Drink.—The processes of digestion go on best at a temperature of about 100° F., and if food be of a temperature much below or above 100° F., the body must bring it to about that temperature before digestion can begin. Cold water is refreshing, but water of a temperature from 45° to 60° is better than water at 32°. When thirsty, drink slowly till the thirst is quenched; do this before meal time so that there will be no temptation to drink while eating, for drink taken while eating prevents good mastication, and hinders stomach digestion by diluting the gastric juice. If drink is taken at meals it should be warm, not cold or hot.

§ 182. The Manner of Taking Food.—Food should be taken slowly, so that it may be well cut and ground and well mixed with the saliva. In such a case the saliva has good opportunity to act upon the starch, and after the food reaches the stomach, the gastric juice can more easily penetrate it, if it be well moistened, just as a moist sponge will take up water more rapidly than a dry one will.

§ 183. THE TIME OF TAKING FOOD.—Food should be taken at regular intervals, for the same reason that muscular exercise should be regular, see § 157. The average time of stomach digestion is about three hours; after the work of digestion, the stomach needs about 3 hours of rest, so that there should be an interval of 5 or 6 hours between meals. This interval is common in all parts of the world for working people. The first meal should be taken within an hour or an hour and a half after rising, and before there has been much exercise, as the blood deprived of its nutrient material by assimilation during the night, cannot furnish support for exercise. The third meal should be taken from two to three hours before retiring; this time allows the completion of digestion, so that when the organs become quiet in sleep there is no undigested food to oppress or disturb them. The second meal, which ought to be the principal meal, should be taken about midway between the other two.

Food should not be taken immediately before or after severe exercise—not just after severe exercise, because so much blood and nervous energy are employed by the muscles that there is not enough to allow the digestive organs to work properly until their distribution has been equalized—not just before severe exercise, as the action of the voluntary muscles will draw blood and nervous energy from the digestive organs, so that they cannot properly digest the food.

§ 184. THE SURROUNDINGS AT MEALS.—There should be plenty of pure air, abundance of daylight, and pleasant companions; the mind should be cheerful, no haste, no worry; in short the conditions and surroundings which are at all times best, must attend us at our meals. In that case mastication will be good and the whole process of digestion will be likely to go on in a proper manner.

§ 185. THE AIR AND ITS IMPORTANCE.—In 100 volumes of chemically pure air there are of oxygen about 21, and of nitrogen about 79 volumes. Such air does not exist in nature. Diffused through the air there are always more or less of water-vapor, carbonic acid, ammonia, nitric acid, gases from decaying animal and vegetable matter, dust of organic and inorganic matter, and germs of animal and vegetable life. An adult man of ordinary activity needs about 17 cubic feet of oxygen per day.

To obtain this amount, from 350 to 450 cubic feet of good air must pass into the lungs every 24 hours. As so much air passes into the lungs each day, it is of great importance that every breath of air should be as nearly pure as possible.

§ 186. THE SOURCES OF IMPURITIES IN THE AIR.—It is impossible to define pure air as furnished by nature, since air that contains no water-vapor is not healthful, and traces of carbonic acid and other gases do not seem to be harmful; but if there exist more than 4 or 5 parts of carbonic acid in 10,000 of air, the air is considered impure. In this case it is a question whether the carbonic acid itself is hurtful, but its presence usually indicates the presence of other gases in dangerous quantities, although they cannot be detected chemically. Combustion, decay of organic matter, and breathing are sources of carbonic acid; decaying organic matters in cesspools, sewers, vaults, around stables, and in marshes give rise to many harmful gases, of which sulphuretted hydrogen is perhaps the most dangerous. Malarial poison arising from marshy districts so contaminates the air that some localities are almost uninhabitable. The damp, confined air of cellars in which there are often decaying vegetables, is a fruitful source of disease. In the air of hospitals, and especially in the air of manufacturing towns, dust of many different substances is found. The dusty air breathed by steel-grinders, by workers in flax or cotton, by brass-founders, match makers, and workers in mercury, and by workers at many other trades, is a prolific source of disease. Of all sources of impurities to the air, the evacuations of living beings are the most important.

§ 187. SOME OF THE EFFECTS OF IMPURE AIR AND WATER.—All diseases to which flesh is subject, either arise from using bad air and bad water, or are much aggravated by such air and water. Air that has been rendered impure by the evacuations from the skin and lungs of living beings is a frequent cause of consumption, scrofula, and of that depressed state of the system which predisposes it to attacks of the various acute diseases. The dusty air of the various workshops and factories is a fruitful source of consumption. Typhoid fever, diarrhœa, dysentery, cholera, diptheria, yellow fever, and other diseases in many cases seem to be caused by impure air or water, and in every case bad air makes the disease more severe, while pure air and water reduce

the mortality, and greatly shorten the time of recovery in all these diseases. An abundant supply of pure air and water is the most important question of a physical nature that humanity is called on to consider.

§ 188. NATURE'S METHOD OF PURIFYING THE AIR.—The various gases which render the air impure diffuse rapidly through the air, so that there is no great accumulation in one place; the winds aid greatly in diffusing gases and dust through the air, so that the impurities are much diluted. Growing plants take vast quantities of carbonic acid and ammonia from the air; the rain washes great quantities of dust from the air, besides dissolving some carbonic acid and other gases which it carries down into the earth, where they combine with elements of the soil or become food for vegetation. In addition to the above, the oxygen of the air is constantly transforming many impurities into harmless compounds.

§ 189. THE AMOUNT OF AIR NEEDED EACH HOUR.—Air that is expired has lost oxygen and gained carbonic acid, water-vapor, and animal matter. It is impossible to tell just how many cubic feet of good air are rendered unfit for breathing by one foot of expired air, but careful experiment and observation show that each adult person engaged in any ordinary occupation needs from 1,000 to 2,500 cubic feet of good air each hour. The following table is from an article by Arthur Morin in the Smithsonian Report for 1873, pages 313 and 314. It shows the amount of air that must be changed for each person every hour to preserve a heathful condition of the air in occupied rooms:

| | | | | |
|---|---|---|---|---|
| In Hospitals during epidemics, . . . . . | about | 3,700 | cubic | feet. |
| In Workshops for unhealthful occupations, | " | 3,500 | " | " |
| In Hospitals for ordinary cases of sickness, from . . . . . . . . . . . . . . | | 2,000 to 2,500 | " | " |
| In Workshops for ordinary occupations, . | about | 2,000 | " | " |
| In Halls for long receptions, . . . . . . . | " | 2,000 | " | " |
| In Lecture rooms, churches, etc. . . . . | " | 1,000 | " | " |
| In Schools for adults, . . . . . . . . . . | " | 1,000 | " | " |
| In Schools for children, (Primary) . . . | " | 550 | " | " |

In all cases the air should be of a temperature of from 60° to 70° F. and its motion should not be perceptible.

§ 189. VENTILATION.—Ventilation consists in removing foul air and introducing fresh air, but as air should be of a proper temperature, warming and ventilation are usually combined, so that ventilation frequently means the removal of foul, cold air and the introduction of warm, fresh air. Good ventilation should furnish cool, fresh air in summer, and warm, fresh air in winter, and its movement should be imperceptible. Occupied rooms should be of such size that each adult is allowed from 400 to 500 cubic feet of air, and each child from 200 to 300 feet. And according to the above table, for each adult, from 18 to 36 cubic feet, and for each child, from 10 to 20 cubic feet of air should be changed each minute. This cannot be done, especially in winter, except by special arrangement, and at considerable cost of fuel.

§ 190. THE PHYSICS OF VENTILATION.—Warm air is lighter, bulk for bulk, than colder air, and the colder, heavier air crowds away the warmer, lighter air, causing currents. What is called "the draft" in a stove is a familiar illustration. In some cases, air is changed by means of currents caused by steam-driven fans, but generally the air of occupied rooms is changed by currents of air caused by the unequal heating of the air. For the proper ventilation of a room, flues and registers should be provided for the entrance of fresh air near the ceiling; and near the floor there should be registers for the exit of foul air, which through collecting passages should communicate with a general discharge flue or chimney. Among the occupants of the room the air should not move more than 2 1-2 feet per second. The quantity of air changed (Q) depends on the area of a cross section of the general discharge flue (A) and on the velocity of the air in the flue (V). The velocity of the air depends on the height of the flue (H), and on the difference between the temperature of the air in the flue (T) and the temperature of the air outside the flue (T'). Stated as an equation, $V = \sqrt{T - T'H}$ and $Q = A\sqrt{T - T'H}$ or $Q = AV$. Friction in the flue modifies velocity somewhat, but in any given case the quantity of air discharged can be increased by increasing the difference between the internal and external temperatures of the general discharge flue, and *vice versa*. The velocity in the general discharge flue should not be more than 6 1-2 feet. A difference between external and internal temperatures of from 36° to 45° F. will usually give the proper velocity.

§ 191. THE NECESSARY AREA OF REGISTERS AND FLUES.—Knowing the amount of air to be changed, and the velocity it should have, the area of the registers and flues can be readily calculated. A room designed for forty children, should have a capacity of 10,000 cubic feet, and fifteen cubic feet of air should be changed each minute for each child, making 600 cubic feet for all per minute, or 10 cubic feet per second. With a velocity of five feet per second this quantity could pass through a main flue having a cross-section of two square feet, and with a velocity of 2 1-2 feet it could pass through registers having an area of four square feet. To insure a steady out-flow from all parts of the room, there should be as many as twelve registers having an area of 48 square inches each. Passages connecting the registers with the main flue should have a larger capacity than the main flues. The fresh-air registers should be of the same number and size. With the proper velocities, each child needs an area of from 12 to 15 square inches for the outlet and inlet of air, while adults need from 20 to 40 square inches.

§ 192. THE DIFFERENT MODES OF WARMING COMPARED.—The ordinary fire-place or grate changes the air in a room very rapidly, but it causes strong currents of air from other parts of the room, and not more than 15 per cent. of the heat of the fuel is utilized in warming the room. A flue, so arranged beside the chimney of a fire-place as to introduce warm, fresh air into the room near the ceiling, will lessen the unpleasant currents and render about 35 per cent. of the heat from the fuel available in heating the room. Flues and registers may be so arranged that almost any ordinary stove can keep the air of a room warm and pure. If there be no special arrangements for ventilation, the air of rooms heated by the ordinary stove must be unhealthful, though nearly 90 per cent. of the heat of the fuel is utilized in warming the room. There are some objections to warming by steam or by hot water, such as leaking pipes, irregularity of heat, complication of apparatus, dry air, etc.; but if the ventilating arrangements are good, the radiating surfaces sufficient, and the furnace fire uniform, rooms may be supplied with fresh air of a proper temperature, without many of the unpleasant circumstances attending the use of stoves or fire-places. Hot-air furnaces in the cellar are frequently used; the arrangements may be such that no ojection can be raised against this mode of heating

and ventilating rooms, but it is too often true that the air sent to the rooms has passed through some foul cellar and over red-hot surfaces, rendering it entirely unfit for breathing. Whatever system of warming is used, be sure that there is a constant and sufficient change of air.

§ 193. HOW TO VENTILATE WITHOUT SPECIAL ARRANGEMENTS.—If in the construction of the room no special arrangements were made for ventilation, an entrance for fresh air can be provided by lowering the upper sash of the windows. The air entering between the sashes will be thrown upward toward the ceiling, and the current of that entering at the top may be broken up by a curtain, or turned toward the ceiling by a sheet of tin, or thin piece of board. A few experiments and a little calculation from §190 will enable one to adapt the size of the opening to the velocity of the current and the number of occupants. A fireplace or grate will remove the foul air with sufficient rapidity, but if the ordinary stove be used, it will be difficult to get rid of the foul air. Keep the door of the stove open as much as possible, and if practicable, have a large pipe put outside the regular stove pipe and connect it with the chimney, or let it open into the attic or through the roof.

§ 194. OTHER MEANS OF PURIFYING THE AIR.—Heat is a very useful agent in purifying air. A temperature of from 140° to 180° F. is very effective in destroying vegetable and animal germs and infectious matters. Direct sunlight is a most efficient means of purifying air that has been rendered impure from any cause. *Carbolic acid* and *Sulphate of Iron* are very effective for disinfecting stables, cesspools, manure heaps, privy vaults, and for destroying animal and vegetable germs, and for arresting putrefactive changes. *Chlorine*, obtained by heating a mixture of common salt and sulphuric acid, *Sulphurous acid*, which is given off from burning sulphur, and *Nitrous acid*, which may be evolved by placing nitre in sulphuric acid, are all powerful disinfectants, but they are poisonous, and rooms in which they have been used must be well ventilated before they are occupied. *Chloralum*, a compound of chlorine and aluminum, is valuable in cleansing infected clothing and rooms. *Charcoal* will absorb and destroy many noxious odors. *Lime* and *chloride of lime* are also valuable disinfectants.

§ 195. Regularity in Evacuating Excretions.—It is essential to health that the excretions from the intestines and kidneys be evacuated regularly. Dejections from the intestines should occur daily, and at a fixed time, and the discharge should be free and copious. Many distressing diseases result from irregularity in attending to this important matter. Excretions from the kidneys must be evacuated more frequently, as often as nature indicates that it is necessary. Evacuation from the lungs, liver, and skin are involuntary and constant. Care should be taken to allow each of the evacuating organs complete freedom of action. Severe diseases occur when either of these organs fails in its action.

§ 196. Clothing.—The various functions of the body are performed best when the body has a temperature of from 98° to 100° F. We wear clothing to aid in maintaining this temperature, as a protection for the skin, and in conformity to social custom. Clothing should meet the above requirements, and at the same time be cheap, light, durable, and easily cleaned. Clothing should allow a free escape of the exhalations from the skin; should retain heat in cold weather, and favor its escape in warm weather; and, while in style clothing should so nearly accord with custom as not to provoke remark, yet it should so fit the body that every organ has perfect freedom of action.

§ 197. The Different Materials for Clothing.—*Linen* is extensively used as an article of clothing. It is durable, easily cleaned, and favors the escape of heat, so that it is much worn in warm weather, especially in direct sunlight. It absorbs the moisture of the perspiration and readily gives it up by evaporation, thus tending to keep the body cool. But the properties which make linen pleasant while exercising in the sunlight, make it unpleasant in the cool of evening or when at rest after exercise. *Cotton* is a very valuable material for articles of clothing. It is not as good a conductor of heat as linen, nor does it absorb or give up moisture as readily, and hence is better than linen for cool weather, and may be worn next the skin with more safety. *Wool* is perhaps more valuable for articles of clothing than either linen or cotton. It is a poor conductor of heat, it is not as easily moistened by the perspiration, and it does not give up moisture by evaporation as readily as either linen or cotton. It

tends to equalize temperature, it protects from sudden chills, and is especially suitable for garments worn next the skin. *Silk* is warm and durable, but costly and not easily cleaned. *Furs* are warm, durable, and costly, but in some climates they are necessary. They will protect from cold when cloth garments utterly fail. *Leather*, used as an outer covering for the feet, is a valuable material for clothing. The shoes or boots made of it should have low, broad heels, and should be broad across the toes, so that the foot is free to retain its natural form, and so that all its parts can act freely.

§ 198. BATHING—ITS NECESSITY AND VALUE.—The water of the perspiration evaporates rapidly, but the solid matter remains on the skin, clogging the ducts, and soon becoming the source of unpleasant, unhealthful odors. To remove this matter from the skin, frequent bathing is necessary. The friction of clothing, of a coarse towel, or brush may aid in removing this matter, but nothing can supply the place of warm, soft water for cleansing the skin. Bathing not only cleanses the skin and promotes its healthful action, but if judiciously used, it protects from colds, and prevents many diseases of the skin, kidneys, stomach, and nervous system; it aids the vital processes; it refreshes and invigorates the whole system.

§ 199. SOME SUGGESTIONS ABOUT BATHING.—In health, if properly taken, a daily bath would be useful; at least one or two each week are necessary. A full bath should not be taken immediately before, nor for two or three hours after a full meal. A warm bath, temperature from 85° to 95° F., is better for all the needs of a healthy person, than either a cold or a hot bath. Do not bathe when much fatigued, and do not remain in the bath longer than from five to fifteen minutes. Before bathing, wet the head thoroughly with cool water and be sure that the feet are warm. After leaving the bath, the water should be quickly absorbed by towels, and friction with towels or with the hands should be kept up till every part of the skin is warm and dry. A short period of rest after a bath will add to its beneficial effects. There are numerous forms of the bath, as the plunge bath, the swimming bath, the shower bath, the sponge bath; any of which may be cold, cool, warm, or hot. The Russian and the Turkish baths are much more elaborate, subjecting one to very high temperatures.

§ 200. How to Bathe.—If practicable, a full warm bath may be taken according to suggestions in § 199, using fine soap as often as necessary for cleanliness. If you cannot take a full bath, the following will be found quite as valuable: Provide yourself with a small tub, a bucket of warm water, a wash bowl, a dish of cold water, towels, and if convenient, a good sponge. Pour a little warm water into the tub, pour some into the bowl and place it on a chair near the tub, step into the tub, wet the head, soap thoroughly all flexions of joints, then with the hands dash the water from the bowl upon the upper part of the body, rubbing it vigorously with the hands as the water runs down; with the sponge, water can easily be applied to the back; continue this till all the warm water is used, then give the body a dash of cold water, dry it quickly, and by friction of the hands and by exercise bring on a glow of warmth over the whole body. This can be done in five minutes, and the effect is as good as that of more elaborate baths. With a good sponge and a little care a good bath may be taken by using only one or two quarts of water, and without splashing walls or soiling carpets.

§ 201. The Bath as a Remedial Agent.—In sickness, bathe as your physician directs. Water is a powerful remedial agent, and intelligently used, aids in curing many diseases. Water is also powerful for harm; many valuable lives have been washed out with water used by ignorant and inexperienced persons. While useful, water is by no means a universal cure-all, as some would have us think; it has its limitations, as do other remedial agents. For a more complete discussion of the uses of water in health and in disease, consult "Uses of Water," by J. H. Kellogg, M. D., of Battle Creek, Michigan.

§ 202. Summary of Hygiene.—To maintain good health, we should observe the following suggestions:

1. We should do a proper amount of work, either physical or mental.

2. We should take a proper amount of rest and sleep.

3. We should take a sufficient quantity of good, well-cooked food.

4. We should be sure to use pure water.

5. We should have an abundance of pure air of a proper temperature.

6. We should be regular in evacuating excretions from the intestines and kidneys.

7. We should keep the skin clean.

8. Our clothing should be such that it will protect from heat or cold, and yet such as will not hinder the evaporation of the water of the perspiration.

9. The clothing and position should be such that every part of the body has the utmost freedom of action.

10. We should never allow any part of the body to become chilled, and should be especially careful to protect the feet from cold.

11. In all things we should be regular and moderate.

12. We should maintain a cheerful countenance, and a conscience void of offense.

§ 203. What to do in Case of Sickness.—If from any cause you are sick, or any one under your care, send immediately for a physician; send for one who is an intelligent, upright, God-fearing man or woman, one who loves his profession and is a good student. In many cases no medicine will be necessary, only a little rest or change of diet; medicine can only aid nature in working a cure, and often does more harm than good. Say to the physician that you would rather pay him his fee for advice not to take medicine, than for advice to take it. Follow the instructions of the physician faithfully. Do not treat yourself till you are very sick and then send for a physician, and demand of him that he make you well; you may be, by delay, beyond human aid. Until the physician takes charge of the case, put the patient in a large, well-ventilated, well-lighted room, keep the feet warm, the head cool, and every thing as quiet as possible.

§ 204. What to do in Case of Accidents.—In case of accidents of any kind, the most important thing to do is to *keep cool;* if it is a case demanding medical or surgical aid, send immediately for a physician or surgeon, sending by the messenger, in writing, a brief account of the accident, so that he can provide himself with all the articles necessary for treating the case. Some things can be done for the sufferer while waiting for professional aid:

1. *In case of Broken Bones or Dislocated Joints.* Put the patient in an easy position, cut away any articles of clothing which may irritate or interfere in the care of the injured part; allow no useless noise; if there is great pain, applications of warm or cold water, as agreeable to the patient, should be made; if the body is cold and the pulse feeble, or if there is a feeling of nausea, some stimulant is necessary; strong hot coffee is good, but brandy may be necessary.

2. *In case of Wounds.* If the blood flows rapidly, as from an artery, compress the artery with the thumb or by knotting a handkerchief and placing it around the limb so that the knot lies over the artery, then tie the ends and twist tight. If the bleeding is from a vein, compress at or below the wound. If the wound is slight, bathe it thoroughly in pure water, bring the edges together and retain them with sticking plaster or a light bandage.

3. *In case of Burns or Scalds.* Remove articles of clothing carefully, and cover the parts with flour, or with cotton saturated with sweet oil. If the injury is extensive, stimulants or opium may be necessary.

4. *In case of Apparent Death by Drowning.* Unless there is danger of freezing do not move the patient, but wipe the mouth and nostrils and remove the clothing to the waist, dry the exposed parts by rubbing with the hands, then give two or three quick, hard slaps over the stomach; if these do not start respiration, then turn the patient on his face, roll up his coat and place it under the stomach, and then press heavily over it on the back, in order to expel the water and other matter from the stomach, throat, and mouth. Turn the patient on his back, and place the coat under it; let an assistant stretch his arms back above his head and hold them, and with a handkerchief hold the tongue out of one corner of the mouth. Then kneel astride the patient, and placing the hands over the stomach and short ribs, press downwards with your full weight while you count three, then relieve the pressure while you count two, then apply pressure again; do this about five times per minute at first, gradually increasing to 15 or 18 times. Continue this for two hours, or until the patient begins to breathe. When the breathing becomes natural, remove all clothing, wrap him in warm blankets, put to bed, and keep him warm and quiet. Give a little hot brandy and water, or other stimulant, every 15 minutes, or as often as may seem necessary.

5. *In case of Apparent Death by Hanging.* If the neck is not broken, remove all clothing to the waist, and dash cold water over the body, then rub dry, and produce artificial respiration as in the case of drowning.

6. *In case of Apparent Death from Foul Air.* The first thing to do is to get the body out of the foul air. Water poured into the well, vat, or other cavity, will dissolve carbonic acid and mix fresh air with the foul; lower a lighted candle into the place, and if it burn brightly, there will be no danger in entering the place, and even should it burn dimly, one might hold his breath long enough to be lowered into the cavity and get a rope around the sufferer. A grappling iron might be used to remove him. When removed, strip the clothing from the throat and chest, dash cold water over the head and chest, rub dry, apply vapor of ammonia to the nostrils, produce artificial respiration, and treat as in drowning.

7. *In case of Apparent Death by Lightning.* Strip the body and dash cold water over it for ten or fifteen minutes, then treat as in case of drowning.

8. *In case of Apparent Death by Cold.* Rub the body with snow, or immerse it in cold water for a few moments, then rub dry, keeping up friction with several pairs of hands, until there is some return of sensibility; when the power of swallowing returns, give mild stimulants, and weak broths a spoonful at a time. Keep the patient in a cold room.

9. *In case of Starvation.* Mild soups should be given at first in small quantities and at frequent intervals, and nothing like a full meal allowed for some time.

10. *In case of Sunstroke.* Place the patient by the window in a cool room, remove the clothing, and pour over the body cold water, beginning with the head and passing to the chest, abdomen, and extremities, and alternate from one part to another, until consciousness returns. Bromide of Potassium is useful for internal medication in cases of sunstroke.

11. *In cases of Injury from Corrosive Chemicals.* Wash the parts thoroughly with plenty of water, then in the case of acids, apply a solution of carbonate of soda; in the case of alkalies, apply some weak acid, as vinegar, or very dilute sulphuric acid.

12. *In cases of Poisoning.* In all cases, give an antidote, something to neutralize the poison, then an emetic to remove the contents of the stomach. Perhaps the best emetic is a tablespoonful of flour of mustard made into a thin gruel with water, which should be taken promptly; before this ceases to operate, the patient should swallow large quantities of warm water or warm milk, so that the poisonous matter may be completely removed from the stomach. For *sulphuric*, *nitric*, and *muriatic* acids, the best antidote is a solution of carbonate of soda given in large quantities. For *oxalic* acid, pulverized chalk mixed with water to the consistency of cream is the best antidote. In case of poisoning by compounds of *antimony*, *arsenic*, *bismuth*, *copper*, *chromium*, *lead*, *mercury*, or *phosphorus*, use large quantities of milk and raw eggs. Calcined magnesia is also good in many cases as an antidote. For *aconite*, *belladonna*, any of the forms of *opium*, *stramonium*, *strychnine*, or any other vegetable poison, give the emetic and warm water freely, and irritate the throat with a feather to induce vomiting. Keep the patient awake. Strong coffee is frequently beneficial. In case of *ivy* poisoning, bathe the parts in sweet spirits of nitre. In case of *mad-dog* or *snake* bites, wash, suck, and cauterize the wound thoroughly, use ammonia or whisky internally. In case of *stings*, remove the sting and bathe the part in cold water, then apply ammonia.

§ 205. TO PREVENT INJURY BY FIRE.—1. *To Prevent Fires.* Keep all matches in tin boxes or in earthen jars; never leave a light burning at your bed side; never put ashes in a wooden vessel; never leave kindling wood or clothing near the stove to dry during the night; never fill lamps after dark; never throw down a burned match until it is extinguished; never leave heaps of oiled rags lying around.

2. *In case Clothing takes Fire.* If your own clothing takes fire, wrap yourself quickly in a bed blanket or some heavy material, and roll on the floor; do not run. If another person's clothing is on fire, wrap a blanket, coat, or shawl about the head and shoulders to smother the flames and to protect the face and lungs, then put the sufferer on the floor and smother out the flames. When this is accomplished, put the patient on a bed and cut away and remove all the clothing possible without tearing the skin, and treat as directed in § 204.

3. *In case a Building takes Fire.* Wherever you are, before you sleep have some definite plan as to how you will escape in case of a fire. If the fire is not in your own room, put on some articles of clothing, as a heavy woolen skirt and shawl, or a pair of pantaloons and heavy coat, and while doing so, decide on some plan of action. Keep windows and doors closed as much as possible. If the smoke is dense, keep near the floor; a stocking wetted and drawn over the face will keep the smoke from the lungs. If you must pass through flames, wrap a blanket about your head and shoulders to keep the flames from your face and lungs. Do not jump from windows, make a rope from the bed clothing and let yourself down by it.

§ 206. CONTAGIOUS DISEASES.—The following from a report of the Michigan Board of Health on Diphtheria contains suggestions which are applicable in the case of any contagious disease:

"Diphtheria is a contagious disease and hence the strict observance of the following precautions is of very great importance:

1. Every person known to be sick with this disease should be promptly and effectually isolated from the public;—one or two persons only should take the entire charge of the patient, and they should be restricted in their intercourse with other persons.

2. The room in which one sick with diphtheria is placed should previously be cleared of all needless clothing, carpets, drapery, and other materials likely to harbor the poison of the disease. This room should constantly receive a liberal supply of fresh air, without currents or drafts directly upon the patient. It will be well also to have the sun shine directly into the room.

3. The discharges from the throat, nose, and mouth are extremely liable to communicate the disease, and should be received on soft rags or pieces of cloth which should be immediately burned.

4. The discharges from the kidneys and bowels are also dangerous, and should be passed on old cloths and burned, or into vessels kept thoroughly disinfected with nitrate of lead, chloride of zinc, or sulphate of iron (copperas), and then be buried at least 100 feet distant from any well. Copperas, dissolved in as little hot water as will dissolve it, is a good disinfectant for this purpose.

5. Nurses and attendants should be required to keep themselves and their patient as clean as possible;—their own hands should frequently be washed and disinfected by chlorinated soda.

6. Soiled beds and body linen should at once be placed in boiling water or in water containing chlorinated soda, chlorinated lime, or a solution of chloride of zinc.

7. All persons recovering from diphtheria should be considered dangerous, and therefore no such person should be permitted to associate with others, or to attend school, church, or any public assembly, until in the judgment of a careful and intelligent physician he can do so without endangering others.

8. The body of a person who has died of diphtheria should, as early as practicable, be placed in a coffin, with disinfectants, and the coffin should then be tightly closed. Afterward, the body should not be exposed to view except through glass.

9. No public funeral should be held at a house in which there is a case of diphtheria, nor in which a death from diphtheria has recently occurred. No children at least, and it would be better in most cases that few adults, should attend such funeral.

10. The room in which there has been a case of diphtheria, whether fatal or not, should, with all its contents, be thoroughly disinfected by exposure for several hours to strong fumes or chlorine gas, or of burning sulphur, and then, if possible, it should for several days, be exposed to currents of fresh air. To disinfect an ordinary room with chlorine gas: .Having tightly closed all the openings of the room, place in it an open earthen dish containing four ounces of peroxide of manganese. Pour on this one pound of strong muriatic acid, being careful not to breathe the fumes. When certain that continuous evolution of chlorine is taking place, leave the room and close the door. To generate sulphurous acid gas, put live coals on top of ashes in a metallic pan, and place on the coals sulphur in powder or fragments. To disinfect 100 cubic feet of air requires the thorough burning of about one and one-half ounces of sulphur.

11. After a death or recovery from diphtheria, the clothing, bedding, carpets, mats, and other cloths which have been exposed to the contagium of the disease, should either be burned, exposed to superheated steam, or to dry heat of 240° F., or be thoroughly boiled.

## Preventive Measures.

1. Avoid the special contagium of the disease.

2. Beware of crowded assemblies in ill-ventilated rooms. All influencies which depress the vital powers, and vitiate the fluids of the body, tend to promote the development and spread of this disease. Among these influences, perhaps the most common and powerful are impure air and impure water; therefore,

3. The grounds under and around the house should be well drained.

4. No vegetable or animal matter should be allowed to decompose on the surface of the ground near the house.

5. If any soap-factory, slaughter-house, rendering establishment, or other source of foul odors, contaminates the air which you and your children daily breathe, take immediate measures, through your local board of health officer, to have such nuisance abated.

6. Your own privy, especially, should at all times be thoroughly disinfected with dry earth, coal ashes, or copperas-water; and the receptacle should be so constructed as to be water-tight and to be tightly covered when removed to be emptied, as it should be often enough to prevent the air about it from becoming offensive.

7. In cold weather so far as possible, your whole house, and especially its sleeping-rooms, should be well ventilated.

8. Your cellar should be dry and well ventilated; it should frequently be white-washed, and always kept clear of decomposing vegetable or other substances.

9. No cess-pools should be allowed near the house. If there be one, it should either be removed or be thoroughly and frequently disinfected with sulphate of iron (copperas).

10 Your house drains should be looked to with scrupulous care, to see that they are well trapped, kept clean, and ventilated into open air.

11. Be sure that your drinking water is not contaminated by surface drainage, nor by leakage from the drain, gas-pipe, sewer, cess-pool, or vault."